BRIGHAM YOUNG UNIVERSITY RESEARCH STUDIES

GEOLOGY SERIES VOL. 7 NO. 7 MAY 1960

FUSULINIDS OF THE CACHE CREEK GROUP STIKINE RIVER AREA, CASSIAR DISTRICT, BRITISH COLUMBA, CANADA

by

Max Grow Pitcher

BRIGHAM YOUNG UNIVERSITY
DEPARTMENT OF GEOLOGY
PROVO, UTAH

FUSULINIDS OF THE CACHE CREEK GROUP

STIKINE RIVER AREA, CASSIAR DISTRICT,

BRITISH COLUMBIA, CANADA

A thesis

submitted to

the Faculty of the Department of Geology

Brigham Young University

In partial fulfillment

of the requirements for the degree

Master of Science

by

Max Grow Pitcher

May, 1960

CONTENTS

LIST OF ILLUSTRATIONS

TABLES

Fusulinid Measurements

FIGURES

PLATES

ABSTRACT

Fusulinids were collected from 2,000 feet of Wolfcampian and Leonardian Cache Creek limestones in the Stikine River Area, Cassiar District, British Columbia.

The Cache Creek group, of which the type section is in the Ashcroft Map-Area, embraces most Upper Paleozoic rocks of British Columbia. Regionally the carbonates overlie thick sections of volcanic tuffs, ribbon cherts, and greenstones, but in the Stikine area the base of the carbonates is concealed. Black Triassic shales overlie the Cache Creek group unconformably.

Previous fusulinid studies from the Cache Creek group reveal Middle and Upper Permian forms with the exception of Pennsylvanian forms described from Ft. St. John, British Columbia.

Various species of fusulinids are compared to those of the McCloud limestone of California, the Akiyoshi limestone group of Japan, and Permian limestones of Sonora, Mexico.

Fusulinids representing four genera, *Schubertella*, *Pseudofusulinella*, *Schwagerina*, and *Parafusulina*, and 15 species are described. Two Leonardian species are new.

INTRODUCTION

Purpose and Scope

Fusulinids of the Cache Creek group have been studied in southern British Columbia and northern Washington (see section below under previous work), but no specific study has been published concerning those in northern British Columbia.

The Cache Creek group of British Columbia includes all Permo-Carboniferous rocks. To this date the Cache Creek group has been studied only from a litho-stratigraphic approach, and of necessity this has been done on a large scale both geographically and stratigraphically.

It is the purpose of this study to establish biostratigraphic zonation on the basis of fusulinids. With this faunal zonation established it is hoped a more definite time-stratigraphic study of the Cache Creek group will be attempted, thus correlating its smaller intervals.

Field Work

Dr. J. K. Rigby suggested the problem in the spring of 1959 when I was hired by Pan American Petroleum Corporation as his assistant. Field work on the Upper Paleozoic rocks of a large area in northern British Columbia was accomplished during the summer of 1959.

Field work was accomplished after reconnaissance flying by helicopter; sections were measured on the ground with a steel tape. Out of some thirty sections measured, two sections - section number 18 and section number 26 - on the south fork of the Scud River, were chosen as the most complete with adequate fusulinid material. Section 18 is a repeat of section 26, but because some of the fossils in section 26 were altered beyond recognition, some of the samples from section 18 were used.

Field work consisted of detailed measurement of the section with steel tape and Brunton compass, and a sampling of each rock unit in the two sections.

Laboratory Work

Laboratory investigation included preparation and study of some 300 thin sections of the fusulinids from the various units, and preparation of insoluble residues in order to look for conodonts and other microfossils.

Thin sections were prepared in the following two ways. The rock was slabbed with a diamond saw, ground down with 120 mesh grit, then polished with 600 mesh powder. An area of abundant fusulinids was then circumscribed, cut out, mounted on a glass slide with Lakeside 40 cement, and then ground down to the requisite thickness for study with a binocular microscope. If there were any oriented fusulinids in thin sections prepared by this method, it was purely by chance.

The second method was to locate individual forms and cut out only a very small piece of the rock and grind it down until the individual fusulinid was oriented properly. This second method was much superior to the first, as it saved time and yielded more sections which were correctly oriented. The value of the first method was in finding forms so small they would otherwise go unnoticed.

Insoluble residues were prepared with 350 cc. glacial acetic acid and 2100 cc. water for a 250 gram sample. These were left until reaction ceased, and were then screened with 100, 60, and 10 mesh screens. The residues were examined for any conodonts, but none were found.

Study of the fusulinids was done by measuring them with a calibrated eye piece on a binocular microscope. Some of the smaller forms were photographed on enlarging paper with magnification of 20 times, and then were measured with a vernier caliper.

To facilitate study of the stratigraphic position of the fusulinids, a chart was prepared by mounting a photograph of each form discovered in its order of stratigraphic occurrence. This was helpful in detecting conspecific forms with different stratigraphic occurrences.

Location and Accessibility

The northern part of British Columbia has not been surveyed sufficiently for township and range, therefore the location is given by longitude and latitude (see also the index map). The section is located approximately at 131°16' longitude and 57°7' N latitude. This is 16 miles due east of the Stikine River, and 54 miles due south of the town of Telegraph Creek, Cassiar District, British Columbia.

The section is an area of difficult accessibility. It is almost impossible to reach this region without the aid of a helicopter. Transportation can be effected via the Stikine River to Telegraph Creek and there is a road extending into Telegraph Creek from the Yukon; however high mountain ranges and crevassed glaciers must be crossed in order to reach the section.

Previous Work

Dawson (1878) examined Cache Creek rocks in the Stuart Lake area, and collected supposedly Carboniferous fusulinids.

Dunbar (1933) restudied the original sections of the foraminifera collected by Dawson in 1876, and definitely concluded Dawson's misidentified foraminifera to be Permian and not Cretaceous, as previously supposed.

The Stikine River area was examined by Kerr (1948) in the years 1926 to 1929 inclusive. He mapped the geology and locally the topography of approximately 2500 square miles for the Canadian Geological Survey. His work was not published until 1948, ten years after his death.

The Canadian survey resumed work in the Stikine area in 1956 under the direction of Dr. Jack Souther. They have subsequently (1957) published a map of the area on the scale of one inch equals four miles.

The fusulinids of the Cache Creek group were identified Middle and Upper Permian by Tompson and Verville (1950). These are the fusulinids from the area near Kamloops, British Columbia.

Thompson and Wheeler (1942) identified very young Permian fusulinids from southern British Columbia, Washington, and Oregon.

In 1950 Thompson, et al., described Middle and Upper Permian fusulinids from Washington and southern British Columbia.

Thompson, Pitrat, and Sanderson (1953) studied the fusulinids of the Cache Creek group from the Fort St. John area and found them to be Pennsylvanian in age.

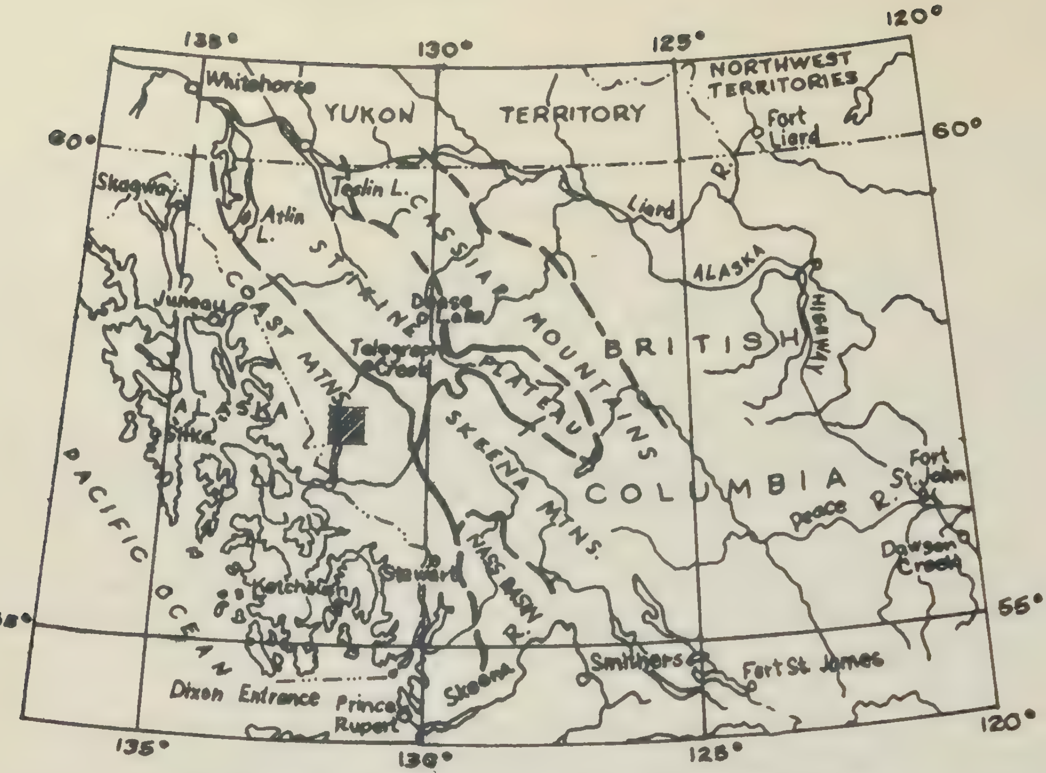
ACKNOWLEDGMENTS

I express thanks to Pan American Petroleum Corporation, Calgary District, by whom I was employed when collections of this material were made. Dr. J. K. Rigby assisted, both in the field and in laboratory consultation. Dr. Harold J. Bissell has contributed freely with loan of his literature on fusulinids and has given constructive criticism of the manuscript, in addition to checking some identifications. Dr. David L. Clark helped with taxonomy. Dr. Lehi F. Hintze offered helpful suggestions with the stratigraphic sections. Dr. George Verville of Pan American Petroleum Corporation, Casper Division, checked some fusulinid identifications.

In the field, Paul Gagnon and Doug Wyllatt assisted in the collection of samples, and David Alder of Okanagon Helicopters gave invaluable service in transportation of personnel and collections.

I also express appreciation to my wife, Diana, who helped with thin sections, photography, and typing of the manuscript.

INDEX MAP



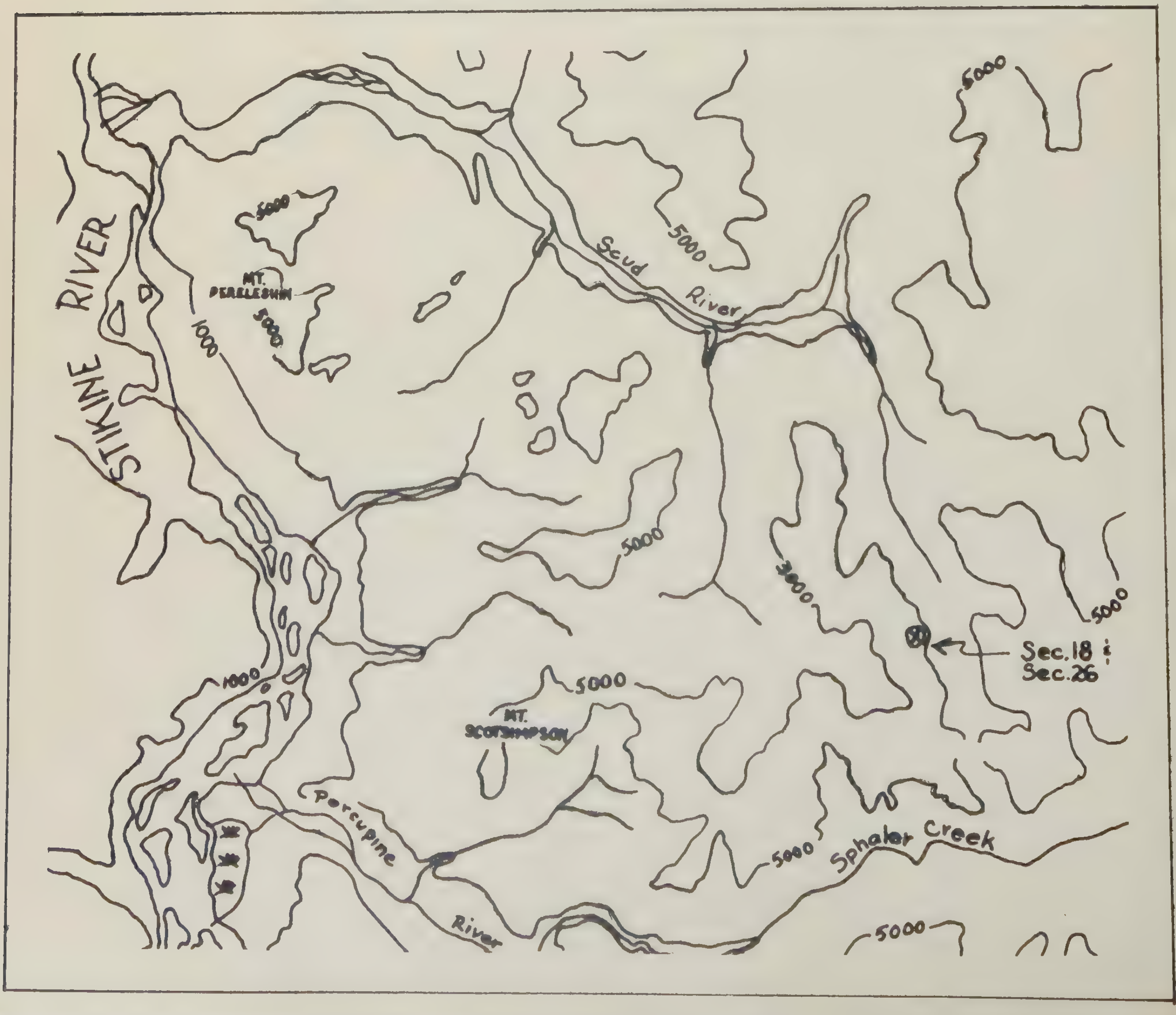


Figure I

STRATIGRAPHY

The Upper Paleozoic rocks of British Columbia have not been described in detail, but are "lumped" into the Cache Creek group which is not a lithologic unit, but is a name applied to most rocks of this age in British Columbia. The Cache Creek group is a thick assemblage, 20,000 feet or more, of interbedded sedimentary and volcanic rocks, mainly of Permian age, but also probably in part of Pennsylvanian age. Regionally this group has a three fold sequence of basal greenstones; medial cherts, argillites, and volcanic tuffs; it also has an upper section of carbonates. Type section of the Cache Creek group is in the Ashcroft Map-area of British Columbia (Selwyn, 1872, pp. 16-72; B of Fig. II).

Below is an index map showing some of the locations in British Columbia from which the Cache Creek group has been described.

A. (Hoadley, 1953)

B. (Jones, 1954)

C. (Armstrong, 1949)

D. (Thompson, et al., 1953)

E. (McLearn, 1950)

F. (Roots, 1954)

G. (Kerr, 1948)

Figure II

Type Cache Creek Group

Rocks of the Cache Creek group underlie an area of about 400 square miles east of the Frazer River. The Cache Creek group consists of a thick assemblage of cherts, argillites, minor amounts of limestones and quartzites, andesite flows, agglomerates and tuffs, and their metamorphic derivatives. It also includes the massive, recrystallized limestones typically exposed in the Marble Canyon and Pavillion Mountains, and known as the Marble Canyon formation. This limestone, forming a distinct subdivision that may be mapped separately, contains minor intercalations of chert, characterized by a predominance of volcanic materials and others by a predominance of chert and argillite.

Type Section

1. Massive limestone (Marble Canyon limestone), with minor intercalations of volcanic rocks, argillites, and cherty quartzites, at least 1,000 feet seen in some exposures. Total thickness probably at least 3,000 feet.

2. Volcanic materials and limestones with some argillites, cherty quartzites, etc. Minimum thickness about 2,000 feet.

3. Cherty quartzites, argillites, volcanic materials, and serpentine with some limestones. The thickness of these beds or part of them was roughly estimated in two places as between 4,000 and 5,000 feet.

Age: (Thompson and Wheeler, 1942): "The Marble Canyon limestones of B. C. and the limestones of central Oregon and Washington which contain Yabeina probably represent the youngest marine Permian known in America" (Duffell, 1952).

The name Cache Creek was first used for a rock unit in 1872 by Selwyn and applied to exposures at Cache Creek and Marble Canyon in Ashcroft Map-area. Owing to a misidentification of some foraminifera collected in the type area the rocks were thought to be Eocene or Cretaceous. G. M. Dawson examined similar rocks at Stuart Lake in 1876 and collected supposedly Carboniferous fusulinids. He correlated the Stuart Lake rocks with Selwyn's Lower Cache Creek (Dawson, 1878, pp. 55-57). Recent re-examination of these fusulinids has shown them all to be a Permian age (Dunbar, 1932; and Thompson and Wheeler, 1942). Rocks lithologically similar to those described

by Selwyn have since been recognized in many areas in British Columbia and have been generally designated as the Cache Creek group or "series". No Cache Creek rocks have, however, been reported in southern British Columbia east of Columbia River and Arrow Lakes (Jones, 1959, p. 30).

Regional Correlation

The following account of the present status and correlation of the Cache Creek group is given by Armstrong (1949), and quoted for the convenience of the reader:

> "As redefined the Cache Creek group has an areal extend of about 3, 500 square miles in the Fort St. James map-area and 500 square miles in the type Ashcroft map-area northwest from Cache Creek. These two map-areas form parts of a discontinuous belt of rocks that are lithologically similar to, and probably of the same age as, the Cache Creek, and that outcrop from the International Boundary at Skagit River northwest more than 550 miles to the headwaters of Omineca River. Areas totalling at least 2, 000 square miles of lithologically similar, non-fossiliferous rocks are exposed between the Ashcroft map-area and the Fort St. James map-area. They form part of a belt broken only by the overlap of Tertiary volcanic rocks at two places between Soda Creek and Vanderhoof. South of the Ashcroft map-area, in the Hope map-area, rocks of the Hozameen group are exposed (Cairnes, 1944). They are lithologically similar to the Cache Creek and probably of the same age, although no fossils have been found in them. The Fergusson group (formerly in part Bridge River series) of the Bridge River area west of the Ashcroft area also comprises lithologically similar non-fossiliferous rocks (Cairnes, 1937, pp. 9-13).
>
> "Exposed on both sides of Thompson River east of Kamloops Lake, and in the vicinity of Shuswap and Okanagan Lakes, are large areas of rocks that may be in part at least correlated with the Cache Creek group (Cairnes, 1940). They comprise assemblages in part lithologically similar to that of the Cache Creek group and they usually contain, in addition to Permian fusulinids, other fossils thought to be probably of Mississippian age. Foraminiferal limestones are characteristic of these

assemblages, but ribbon cherts are poorly represented. The fossiliferous beds of the Chilliwach group of southwestern British Columbia may be correlated with the Cache Creek group. Fossils were collected by Daly and examined by Girty (Daly, 1912, p. 515), who compared them with those of the Nosoni formation of northern California, which was originally considered to be of Carboniferous age but now regarded as Permian (Thompson, Wheeler, & Hazzard, 1946, pp. 1-11). Daly (Daly, 1912, pp. 514-515) states that the lower, non-fossiliferous members of the Chilliwach group may belong to one or more systems older than the one represented by the fossiliferous beds. The Chilliwach group contains no ribbon cherts.

"The Slide Mountain group (Johnston, 1926, pp. 18-21) of the Cariboo may be in part correlated with the Cache Creek group, but may be in part older. It has been divided into four members: the Guyet conglomerate, 900 feet thick at the base; the Greenberry limestone, 400 feet thick; the Waverley basic volcanic rocks, 2,000 or more feet thick; and, at the top, the Antler ribbon cherts and argillites, 3,500 or more feet thick. Except for the basal Guyet conglomerate this group is very similar to the Cache Creek. Fossils of doubtful Mississippian age were collected from the Greenberry formation, but as the collections were unsatisfactory it is quite probable the fauna is post-Mississippian in age. Johnston and Uglow believed that the Slide Mountain group was equivalent to the lower part of the Cache Creek group.

"The upper part of the Dease group of northern British Columbia is lithologically and palaeontologically similar to the Cache Creek group (Hanson & McNaughton, 1936, p. 5; 82, p. 81). It is composed of the typical ribbon cherts, foraminiferal limestones, argillites, and greenstones, and contains fossils of Permian age. The lower part of the Dease group may, however, be as old as Ordovician.

"The Asitka group of the McConnell Creek area (Lord, 1949), which joins the Fort St. James area on the northwest, contains limestones from which foraminifera of Lower Permian and possible Pennsylvanian age have been collected, indicating the same age for this group as

that assigned to the Cache Creek group. However, the two groups are lithologically dissimilar, and are separated by a fault, so that their structural relations to one another are unknown.

"The Braeburn foraminiferal limestones of northwestern British Columbia and southwestern Yukon may be correlated with the Cache Creek group (Cairnes, 1910, p. 29; 37, p. 53), and the Taku group of the same area contains an abundance of ribbon chert and may be of the same age (Cairnes, 1913, pp. 52, 53).

"Clapp (Clapp, 1912, pp. 43-44) correlated the Leech River formation of southern Vancouver Island with the Cache Creek group, although he found no fossils. Permian and probable Pennsylvanian fossils were collected by Gunning (Gunning, 1931, p. 59) from limestone lenses in volcanic rocks in the Buttle Lake region of central Vancouver Island. These rocks may also be correlative with the Cache Creek group.

"Permian limestones in Washington and Oregon, such as the Granite Falls limestone (Anderson, 1941), contain a fusulinid fauna similar to that of the Marble Canyon limestones of the Cache Creek group" (Armstrong, 1949, pp. 50-51).

Cache Creek Group of the Stikine River Area

Carbonates are the only Cache Creek rocks exposed in the Stikine River area. The base of these Early and Middle Permian rocks is not exposed in this area, but in other areas they overlie volcanic tuffs and ribbon cherts of an undetermined age.

The section studied forms a massive ridge separating two glaciers. It is faulted at the base where the massive limestone of the top of the section is repeated. From the base of the section upward, the limestones are calcarenites of bioclastic material.

Residues prepared from some units yield a high percentage of insoluble material, while others yield very little.

The section is cut by a few minor diorite dikes which have formed a small alteration zone.

In the upper part of the section the rocks are more cherty. The cherts are both nodular and bedded. Nodular chert is often darker than the bedded chert. Chert which forms beds is usually very light gray to white or light yellow in color. Typical chert beds are eight to ten inches thick. The bedded chert appears to be primary, and the nodular secondary. Commonly the fossils are the only parts of the rock replaced by the silica.

Dolomites are common in the upper half of the section. These appear to be diagenetically altered rocks with various gradations of dolomitization. Fossils are rare or non-existent in the dolomites.

The upper 800 feet of the section is a very unusual limestone. It is very light gray to white and composed of a fossil hash of cryptostome bryozoans, small crinoids, small brachiopod remains, and a few fusulinid fragments. The fossil remains are only slightly abraded and are cemented by a micritic calcite cement. The rock has a porcelainous to translucent appearance. Bedding is very obscure but appears to be massive. This unit breaks into angular blocks and forms a semi-ledge zone.

A fifty foot diorite body intrudes the section above this limestone. Stratigraphy and topography above the section are covered by ice and snow.

The section just described is repeated higher on the ridge and is numbered section 18, or Scud River Upper Section. The repetition is detected by the reoccurrence of the characteristic upper massive limestone. Paleontologically, however, only the long ranging fusulinids, <u>Pseudofusulinella occidentalis</u> (Thompson and Wheeler) and <u>Schwagerina cf. S. modica</u> Thompson and Hazzard, are found repeated in the upper section. Because the fusulinids which occur the highest in section 18 are new species, it is not known if the section is repeated by folding which would have reversed the stratigraphic sequence, or by reverse faulting which would have repeated the upper section in its natural order. On the basis of size, undulating spirotheca, and intensity of septal fluting of <u>Parafusulina n. sp. A</u> and <u>P. n. sp. B</u>, Mr. George Verville has indicated (personal communication) that they are younger forms than <u>P. cf. P.? calx</u> Thompson and Wheeler, which occur below. If this is the case then the section is repeated by faulting and is not overturned. However, the possibility of an overturned section due to folding cannot be disregarded.

The fusulinids illustrated on figure III are a composite of sections 26 and 18. All species up to <u>P. cf. P.? calx</u> are from

section 26, and those from P. cf. P. ? calx to P. n. sp. B inclusive are from section 18. This is necessary because the upper part of section 26 is dolomitized so that the fossils are not recognizable.

The Cache Creek group experienced pre-Triassic folding and erosion, so that the black Triassic shales are unconformable on the Upper Paleozoic strata. This post-Permian erosional surface left "islands" of Upper Guadalupian strata throughout British Columbia.

Most of the previous fusulinid studies made in the Cache Creek group have been done on the younger Permian strata (see section above on previous work). With the exception of Pennsylvanian fusulinids found in the Fort St. John area (Thompson, et al., 1953), the Wolfcampian and Leonardian fusulinids of the Scud River sections are some of the oldest described from the Cache Creek group.

Stratigraphic Occurrence of the Fusulinidae from the Scud River Area

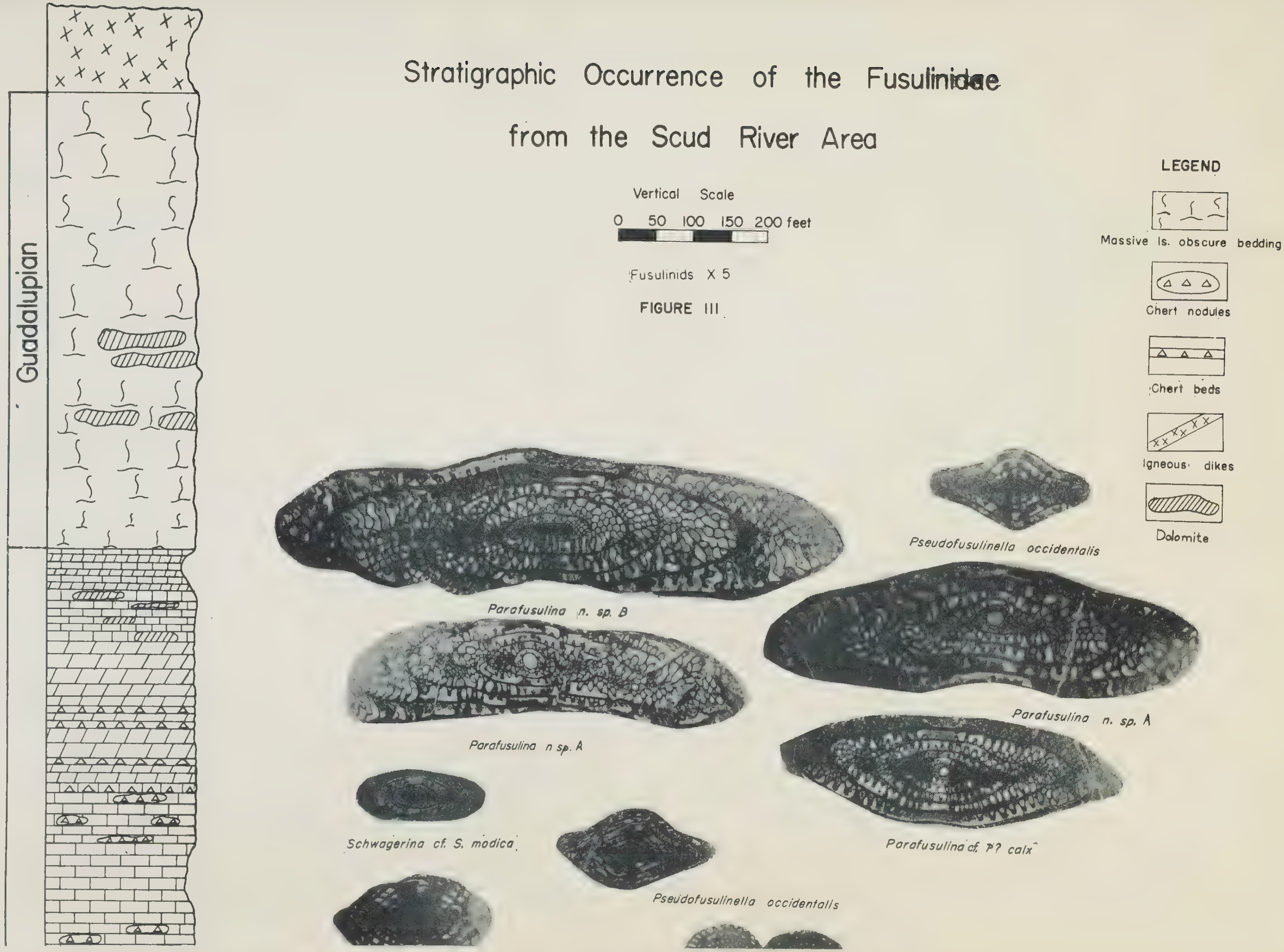
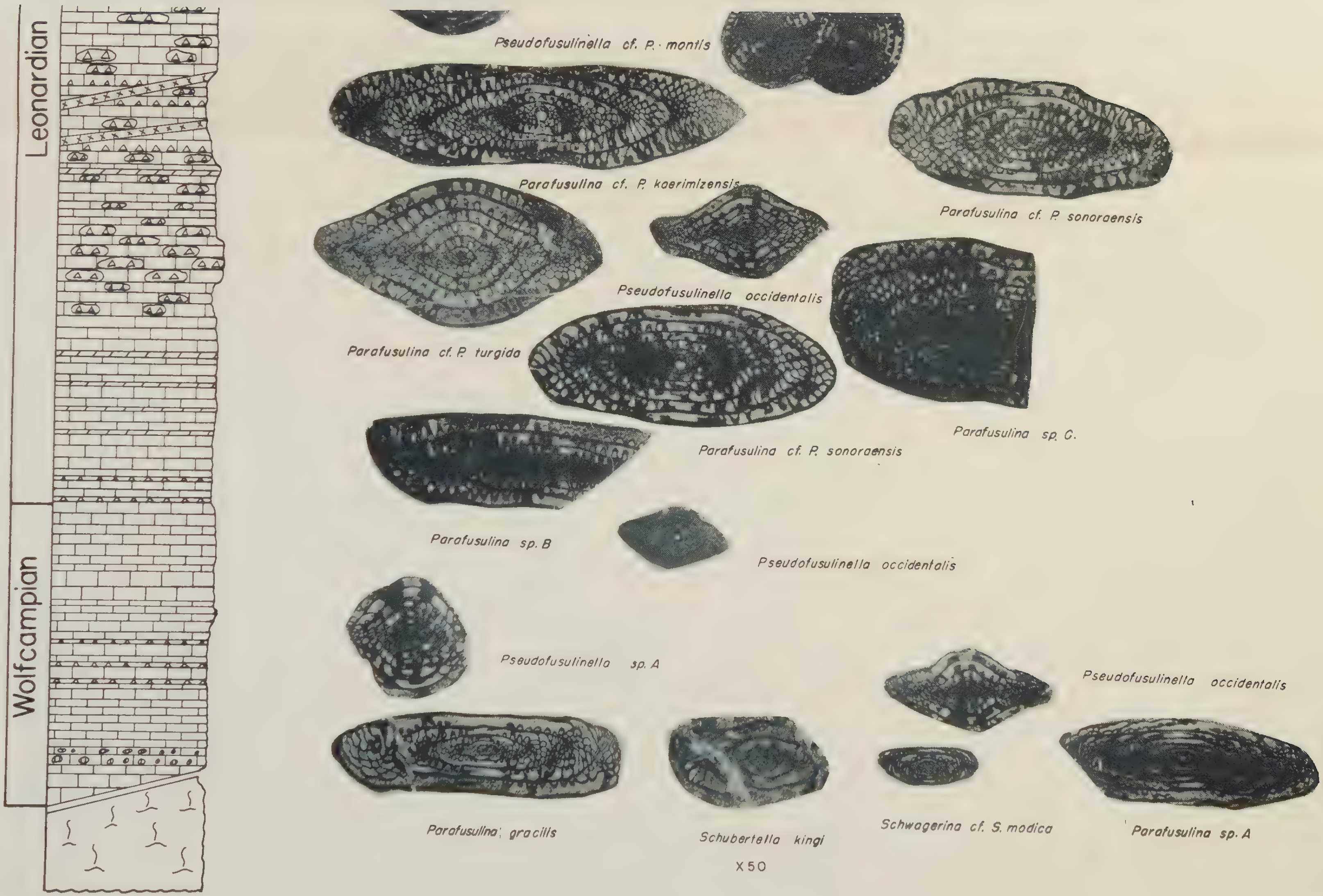
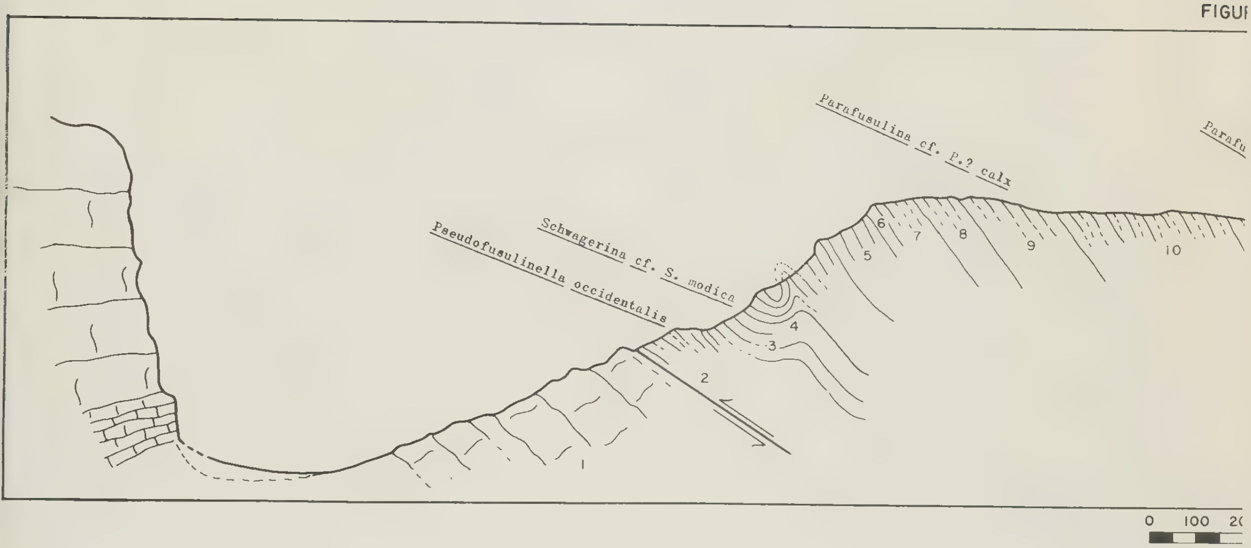


FIGURE III


Leonardian
Wolfcampian
Pseudofusulinella cf. P. montis
Parafusulina cf. P. koerimizensis
Parafusulina cf. P. sonoraensis
Pseudofusulinella occidentalis
Parafusulina cf. P. turgida
Parafusulina sp. C.
Parafusulina cf. P. sonoraensis
Parafusulina sp. B
Pseudofusulinella occidentalis
Pseudofusulinella sp. A
Pseudofusulinella occidentalis
Parafusulina gracilis
Schubertella kingi
Schwagerina cf. S. modica
Parafusulina sp. A
X 50

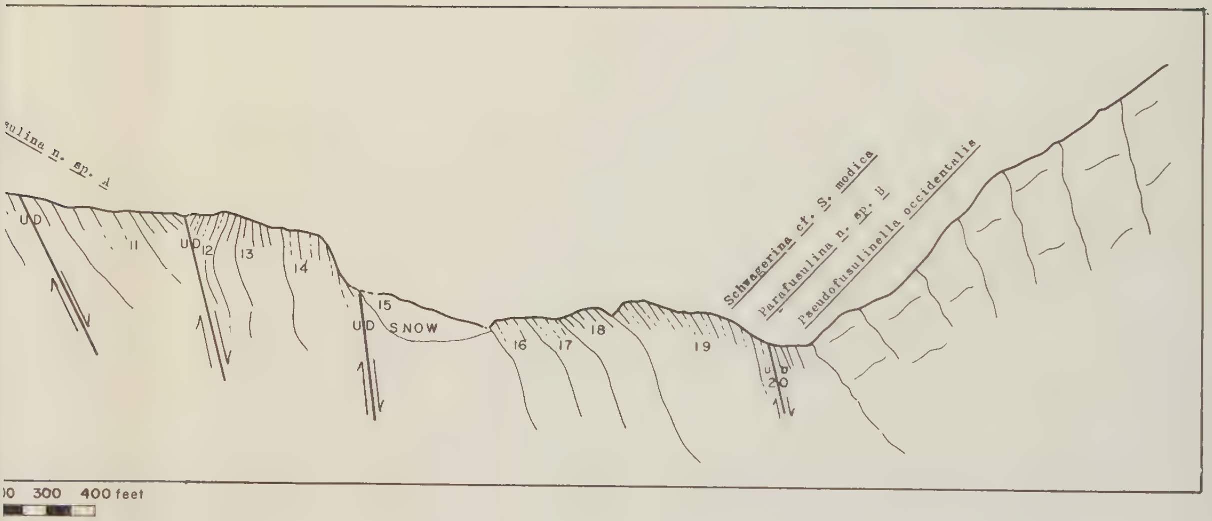
FIGUI



Scud River

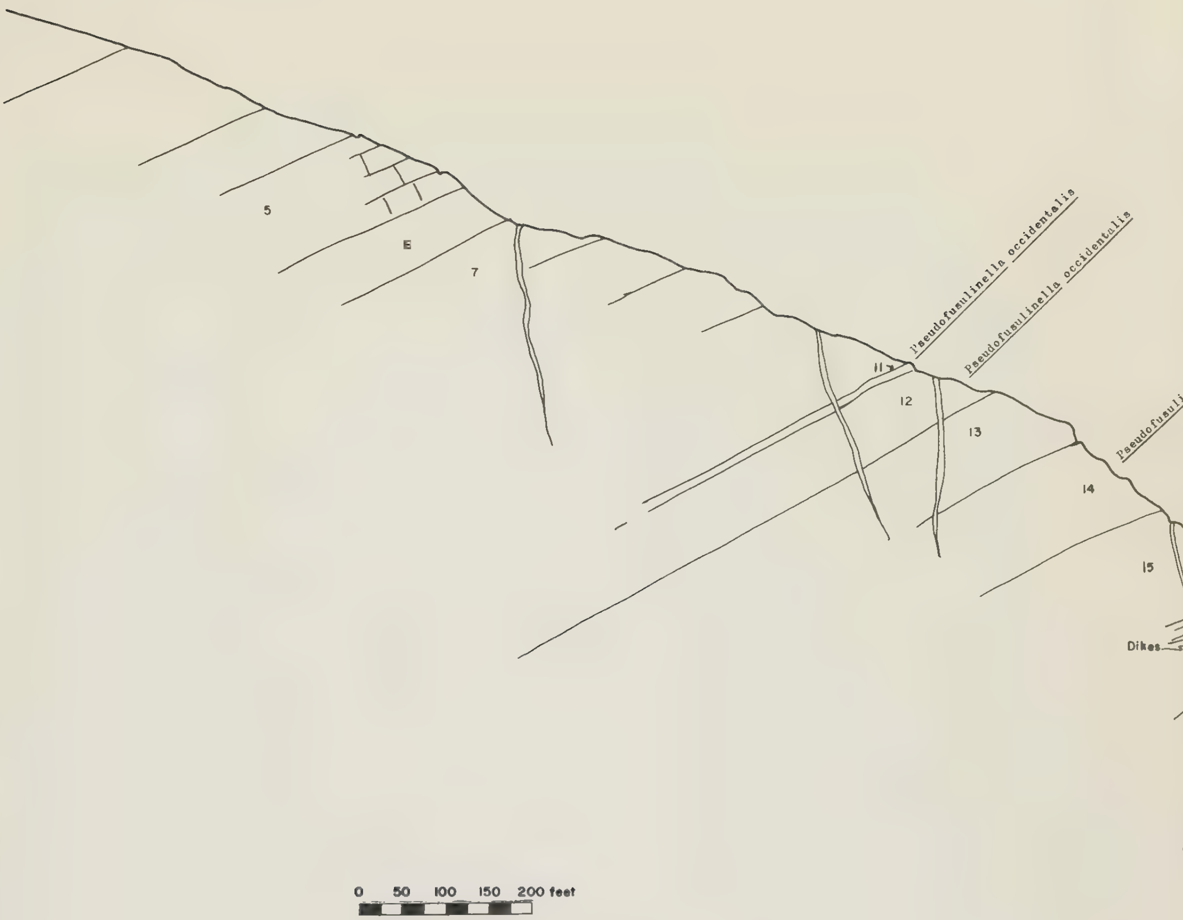
(Sec.

ꞮE IV



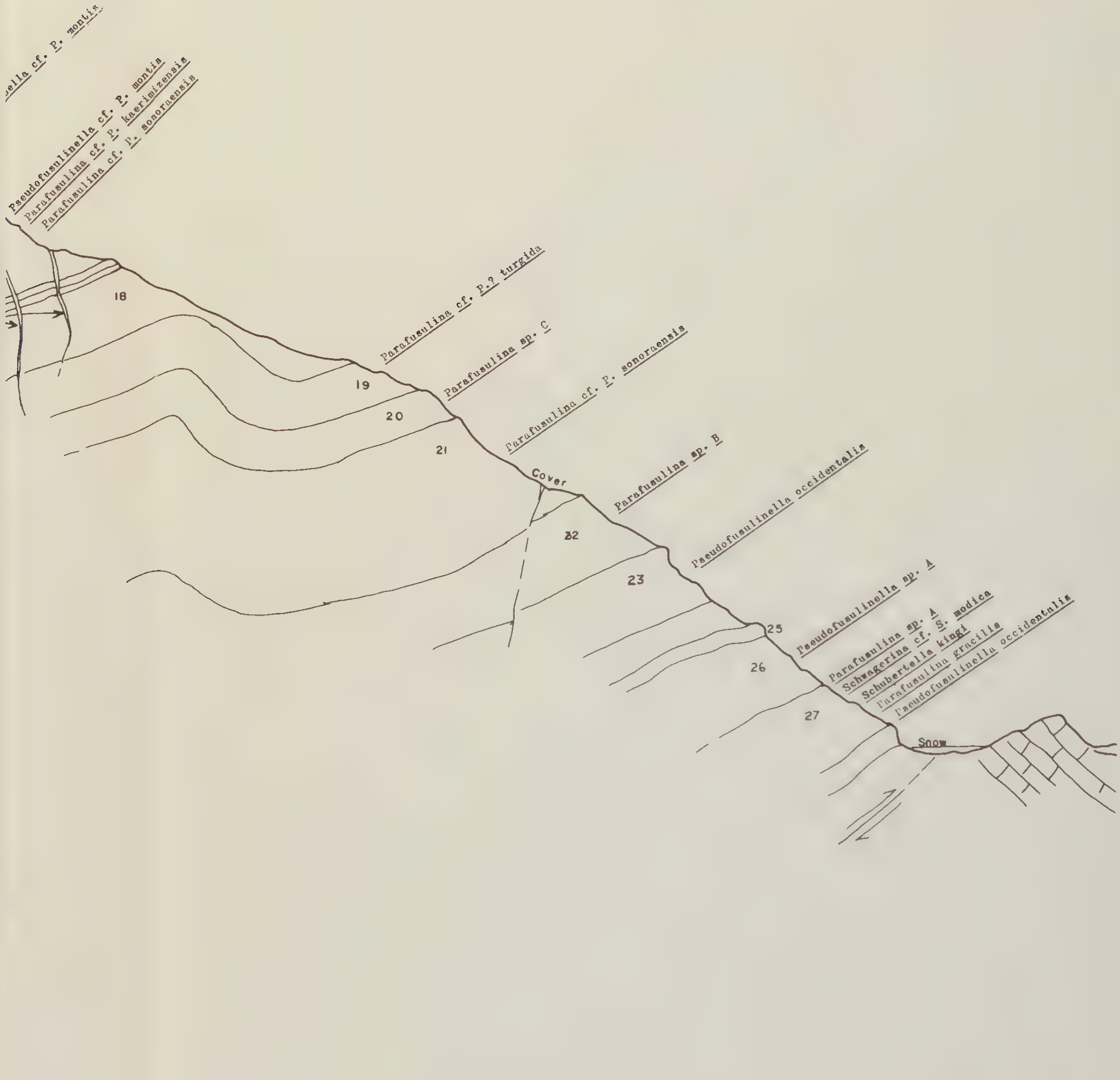
Upper Section

18)



Scud River Lower Section
(Sec. 26)

FIGURE V



ella cf. P. montis
Pseudofusulinella cf. P. montis
Parafusulina cf. P. kaerimizensis
Parafusulina cf. P. sonoruensis
18
Parafusulina cf. P.? turgida
19
Parafusulina sp. C
20
Parafusulina cf. P. sonoruensis
21
Cover
Parafusulina sp. B
22
Pseudofusulinella occidentalis
23
25
Pseudofusulinella sp. A
26
Parafusulina sp. A
Schwagerina cf. S. modica
Schubertella kingi
Parafusulina gracilis
Pseudofusulinella occidentalis
27
Snow

FAUNAL CORRELATION

Because no previous fusulind studies have been made from any Wolfcampian and Leonardian sections of the Cache Creek group it was necessary to go beyond British Columbia for faunal correlation.

In comparing fusulinid studies it became apparent that the McCloud limestone and the Bird Springs formation of California (Thompson, Wheeler, and Hazzard, 1946) are approximately the same age as the Cache Creek limestones of the Stikine River area. Consequently many of the names here given to the fusulinids are from the California study. Many of the forms described in this work vary slightly in size from those described from California, but in general there are sufficient similarities to consider them as being conspecific.

Parafusulina kaerimizensis (Ozawa) has previously been found only in Japan, but could have migrated to North America by way of the Tehyan seaway (Thompson, 1950, pp. 46-47).

Schubertella kingi Dunbar and Skinner, was described first from the Hueco limestone of the Hueco and Sierra Diablo Mountians, Texas; but it appears to have almost universal occurrence.

Parafusulina sonoraensis Dunbar, is described from Sonora, Mexico (Dunbar, 1939).

The fauna of this area is different from that found in the west Texas area and was probably isolated by the same barrier that separates Californian fusulinids from those of Texas.

The two collecting locations for this study are referred to as section 18 and section 26. These are given Brigham Young University location numbers of 12023 and 12024 respectively. Individual specimens are also given Brigham Young University, Geology repository numbers from 539 - 596 inclusive.

SYSTEMATIC PALEONTOLOGY

Family FUSULINIDAE Möller, 1878

Subfamily SCHUBERTELLINAE Skinner, 1931

Genus *Schubertella* Staff and Wedekind, 1910

Schubertella kingi Dunbar and Skinner
(Plate 1.)

Shell minute, fusiform; bluntly rounded poles; axis of coiling is slightly curved. Single specimen of five volutions. 1.1 mm. long and .42 mm. wide. Inner two volutions endothyroid.

Septa present in axial region; slightly fluted in polar regions.

Spirotheca thin and composed of one layer. Chomata faintly visible in inner three volutions.

REMARKS: *Schubertella kingi* Dunbar and Skinner was described from the lower Hueco limestone of the Hueco and Sierra Diablo Mountains, Texas, but is almost universally distributed with Wolfcampian fusulinids. Only one specimen was observed.

OCCURRENCE: *S. kingi* Dunbar and Skinner was collected from the base of unit 27, 30 feet above the fault at the base of section 26. This form occurs with *Parafusulina gracilis* (Meek), *Parafusulina sp. A*, *Schwagerina cf. S. modica* Thompson and Hazzard, and *Pseudofusulinella occidentalis* (Thompson and Wheeler).

Repository: Brigham Young University Paleontology Collection, 12024-581.

Subfamily FUSULININAE Rhumbler, 1895

Genus Pseudofusulinella Deprat, 1912

Pseudofusulinella sp. A
(Plate 2.)

Shell small, highly inflated, fusiform; appears nearly spherical. Single specimen 4.24 mm. long, 3.58 mm. wide. Form ratio 1:1.19. Specimen contains 9 volutions. Prolocus minute.

Septa present in axial region, fluted slightly at the polar regions.

Chomata very heavy, reaching to the top of chamber. Chomata slightly assymetrical in outer volutions.

REMARKS: Pseudofusulinella sp. A resembles P. occidentalis (Thompson and Wheeler) and P. montis (Thompson and Wheeler) of the McCloud limestone of California. P. sp. A, however, is more inflated than P. occidentalis and has fewer volutions and less chomata than P. montis. Only a single specimen was not silicified beyond recognition.

OCCURRENCE: This form occurs in unit 26, 190 feet above the fault at the base of section 26. P. sp. A is Wolfcampian in age. No other fusulinids were collected with P. sp. A.

Repository: Brigham Young University Paleontology Collection, 12024-586, 585.

Genus Pseudofusulinella Thompson, 1951

Pseudofusulinella cf. P. montis
(Thompson and Wheeler)
(Plate 2, table 2)

Shell small, inflated fusiform. Straight axis of coiling. Steep lateral slopes. Mature specimens 10 - 12 volutions; length 3.0 - 5.0 mm., width 2.5 - 3.6 mm. Form ratio about 1:1.3 - 1:1.5. Inner 5 or 6 volutions quadrate to diamond shaped, becoming bulbous. Form ratio of fourth volution averages 1:1.4; of sixth volution 1:1.4; of eight 1:1.4, and of twelfth volution 1:1.3.

Proloculus small, outside diameter 166 - 200 microns. Shell expands uniformly.

Septa are thin and numerous. Septal count of first to seventh volutions in a typical specimen is 9, 15, 17, 17, 23, 28, 29, respectively. Septa straight across middle part of shell, but fluted in extreme polar regions.

Tunnel high and narrow, its path slightly irregular. Chomata are well developed in all portions of shell. Chomata are perpendicular to chamber floor on tunnel side, but on poleward side they slope toward the floor with a much more gradual angle. The chomata occupy from three-fourts to totally the chamber area. They are elongated and very pronounced. Average tunnel angles for the first to twelfth volutions in three typical specimens are respectively 11°, 15°, 11°, 11°, 10°, 9°, 10°, 9°, 11°, 13°, 15°, 12°.

Spirotheca thin, composed of three layers - an upper layer which seems to correspond to an upper tectorium of other fusulinids; a tectum, and a lower layer which seems to correspond to diaphanotheca of other fusulinids. Thickness of spirotheca of a typical specimen from first to eleventh volutions is 20, 33, 20, 40, 66, 66, 70, 72, 72, 66, 66 microns.

REMARKS: The forms described here are somewhat smaller than those described by Thompson and Wheeler from the McCloud limestone of California. However the over all shape, number of volutions, and heavy chomata are similar in both. This form compares with *Pseudofusulinella sp. A* of unit 26, but differs with its heavier chomata and greater number of volutions. *Pseudofusulinella occidentalis* (Thompson and Wheeler) is much more elongate in polar regions and has fewer volutions than *P. cf. P. montis* (Thompson and Wheeler).

OCCURRENCE: The zone of *P. cf. P. montis* (Thompson and Wheeler) starts 920 feet from the base of section 26 and extends upward for 150 feet. This is in the middle Leonard. *P. cf. P. montis* does not occur in the same rocks as any of the other fusulinids.

Repository: Brigham Young University Paleontology Collection, 12024-547, 548, 549, 550, 551, 552, 586.

Genus Pseudofusulinella Thompson, 1951

Pseudofusulinella occidentalis (Thompson and Wheeler)
(Plate 2, table 1)

Shell small, inflated fusiform; sharply pointed poles, and straight axis of coiling. Mature specimens of 8 - 9 volutions. 3.6 - 5. mm. long, 1.8 - 2.8 mm. wide. Form ratio 1:1.8 - 1:2.2. Average form ratio for five specimens is 1:2.0. Average form ratio for first, third, and fifth volutions respectively 1:1.5, 1:2.1, and 1:2.1. Inner 5 or 6 volutions quadrate in outline, but polar regions in seventh to ninth volutions become greatly extended.

Proloculus minute, from 40 - 133 microns in outside diameter. Average outside diameter is 102.4 microns. Shell does not expand uniformly, as first 3 - 4 volutions are tightly coiled and beyond this the chambers are more highly inflated.

Septa thin and numerous. Septal count of volutions one to eight in a typical specimen 9, 16, 18, 22, 24, 26, 29, 31, respectively. Septa are broadly wavy in central part of shell. Poleward from center of shell, fluting increases in intensity and in polar regions it forms chamberlets in basal part of chambers. Fluting is axial.

Tunnel narrow, relatively high, and its cross section is almost square. Average angles for volutions one to six in six specimens respectively 15°, 17°, 19°, 20°, 21°, 22°. Chomata well developed throughout all volutions. Chomata range from two thirds to totally the height of the chambers. Tunnel sides of chomata are essentially vertical, while poleward sides are at a slightly smaller angle sloping toward poles. This is true especially in the eighth and ninth volutions. The chomata become wider in the outer three volutions.

Spirotheca thin, composed of three layers; one upper layer which seems to correspond to upper tectorium of other fusulinids, a tectum, and a diaphanotheca (plus a lower tectorium). Average thickness of spirotheca in six specimens, volutions one to nine respectively - 17, 24, 32, 41, 36, 49, 55, 67, 58 microns.

REMARKS: P. occidentalis (Thompson and Wheeler) of this area has a great variability in size. Some forms found are very small, but contain large proloculii. Most of the P. occidentalis (Thompson and Wheeler) are slightly larger than those described from the McCloud limestone of California (Thompson, Wheeler, and Hazzard, 1946).

P. occidentalis resembles Pseudofusulinella sp. A and P. cf. P. montis (Thompson and Wheeler), but is not so ovate. P. occidentalis has more sharply pointed poles, lighter chomata, and smaller shell.

OCCURRENCE: The first appearance of P. occidentalis (Thompson and Wheeler) is in the top of unit 27, 100 feet above the base of section 26. From here it is encountered frequently (in various places) higher in the section, and in section 18. This species is found just above the most primitive species of Parafusulina, P. cf. P. gracilis (Meek), and with the youngest parafusuline found - Parafusulina sp. A. None of the three species of Pseudofusulinella here described occur together.

Repository: Brigham Young University Paleontology Collection, 12024-539, 540, 541, 542, 543, 544, 545, 546, 584.

Subfamily SCHWAGERININAE Dunbar and Henbest, 1930

Genus Schwagerina Möller, 1877

Schwagerina cf. S. modica Thompson and Hazzard
(Plate 1, table 3)

Shell small, cylindrical fusiform with low lateral slopes and rounded poles. Mature specimens have 5 - 6 volutions, are 3. - 4. 4 mm. long, 1. 2 - 1. 6 mm. wide. Form ratio 1:2. 5 - 1:2. 9. Average form ratio 1:2. 2. Average form ratio of first volution is 1:1. 4, of third volution 1:1. 9. Axis of coiling is straight.

Proloculus relatively small, outside diameter ranging from 100 - 167 microns. Average outside diameter for same four specimens is 118. 5 microns. Shell expands uniformly.

Septal count for first to fourth volutions in a typical specimen is 7, 13, 15, 17. (Repository number 553.) Fluting extends throughout the length of the shell. In center of shell fluting forms chamberlets reaching half the height of the chamber, but increase in polar regions.

Tunnel low, broad in outer volutions. Angles remain constant in first, second, and third volutions, but increase in the fourth volution. Average tunnel angle in first three volutions is 30°, average tunnel angle in fourth volution is 59°. Chomata is not visible.

Spirotheca are thick, have broadly undulating surface. Averages of thickness of five typical specimens from first to fifth volutions are 13, 22, 37, 40, 72 microns. Spirotheca composed of tectum and relatively thick keriotheca. (Keriotheca relatively thick in relation to size of specimen).

REMARKS: This species is referred to Schwagerina modica Thompson and Hazzard with question. This form is much smaller, but appears to have the same characteristics. S. cf. S. modica may be an infant parafusuline, but its repeated appearance in the section indicates an adult individual. There are no other fusulinids found in these sections which resemble Schwagerina cf. S. modica Thompson and Hazzard.

OCCURRENCE: Two specimens of this species were found with Parafusulina sp. A, Parafusulina gracilis (Meek), and Schubertella kingi Dunbar and Skinner. A few other specimens were collected.

Repository: Brigham Young University Paleontology Collection 12024-553, 554, 555, 556, 582, 583.

Genus Parafusulina Dunbar and Skinner, 1931

Parafusulina gracilis (Meek)
(Plate 1, table 5)

Shell small to medium, elongate, cylindrical fusiform, with broadly rounded poles. Straight axis of coiling. Mature specimens contain 5 - 6 volutions; 712 to 10. 7 mm. long, 1. 7 to 2. 7 mm. wide. Form ratio 1:4. - 1:4. 1. Average form ratio about 1:4. Form ratio of first volution is about 1:1. 7, of third 1:2. 7.

Proloculus is small, outside diameter of 100 - 273 microns, average outside diameter of about 186. 5 microns for 2 specimens. Shell expands uniformly.

Septa highly fluted and slightly irregular. The septa form chamberlets which reach to wall of next volution in the inner volution, but form low chamberlets in last volution.

Tunnel is low and broad. Tunnel angle increases more rapidly from second to third volutions than in first to second volutions; is about 38° in first volution, 45° in second volution and 67° in third volution. Chomata very thin in first two volutions, but is not observed in outer volutions.

Spirotheca fairly thick, composed of tectum and thick keriotheca. Average spirothecal thickness in first to sixth volutions respectively, is about 22, 37, 44, 67, 83, 73 microns.

REMARKS: Meek (1864) first described this form, however his specimens are apparently lost. Thompson (1946) therefore described a neoholotype from the McCloud limestone of California.

Parafusulina gracilis (Meek) is the most primitive parafusuline so far recognized. However, the cuneculi prove it to be a parafusuline. Its association with other Wolfcampian forms such as *Schubertella kingi* Dunbar and Skinner, prove it to be pre-Leonardian.

P. gracilis (Meek) resembles *Parafusulina sp. A*, but has more rounded poles, fewer volutions, and relatively low chambers immediately over the tunnel.

OCCURRENCE: The first exposed limestone above the fault at the base of section 26 is a coquina of *P. gracilis* (Meek). This is in the first 20 feet of unit 27, approximately 30 feet above the fault. *P. gracilis* occurs with *P. sp. A*, *Schwagerina* cf. *S. modica* Thompson and Hazzard, and *Schubertella kingi* Dunbar and Skinner. The *P. gracilis* zone ends as the *Pseudofusulinella occidentalis* (Thompson and Wheeler) zone begins.

Because *Pseudoschwagerina* is not found above *P. gracilis*, the *P. gracilis* zone is assumed to be upper Wolfcampian.

Repository: Brigham Young University Paleontology Collection, 556, 560, 581.

Parafusulina sp. A
(Plate 1, table 4)

Shell small, elongate cylindrical fusiform with slightly rounded poles. Axis of coiling is essentially straight. Mature specimens have 6 - 7 volutions, 8. - 9. mm. long, and 2.4 - 2.7 mm. wide. Form ratio of two typical specimens is 1:3. - 1:3.7. Average form ratio for same specimens 1:3.4. Average form ratios of first, third, and fifth volutions respectively, are 1:2., 1:2.7, 1:3.3.

Proloculus is small, outside diameter in a typical specimen is 200 microns, shell expands uniformly.

Septal count for typical specimen (26-27-18) for volutions 1 to 6, is respectively 9, 13, 18, 20, 23, 25.

Tunnel is broad and low, path essentially straight. Average tunnel angles for the first five volutions are 46°, 36°, 41°, 58°, 60°.

Spirotheca is even, composed of tectum and keriotheca. Average thickness of spirotheca from first to seventh volutions of two specimens 23, 40, 50, 59, 53, 76, 115 microns respectively. Height of volutions expands slightly over the tunnel.

REMARKS: Parafusulina sp. A resembles P. gracilis (Meek) in size, but is wider. Where the volutions of P. gracilis (Meek) are deflated over the tunnel, P. sp. A is inflated. P. sp. A has more volutions than P. gracilis (Meek).

No cuneculi were observed in P. sp. A, but the regular spirotheca and septa indicate it to be a parafusuline.

OCCURRENCE: P. sp. A occurs at the base of unit 27, 30 feet above the base of section 26. This species occurs with abundant P. gracilis (Meek), a few specimens of Schwagerina cf. S. modica Thompson & Hazzard, and Schubertella kingi Dunbar & Skinner.

Repository: Brigham Young University Paleontology Collection, 12024-557, 558, 559.

Parafusulina sp. B
(Plate 1)

Shell large, elongate, cylindrical, with rounded poles. Single specimen 15 mm. long, 3.2 mm. wide for 4 volutions.

Proloculus small, 180 microns. Septa regularly fluted throughout shell, forming narrow chamberlets which reach to the top of chambers. Secondary axial deposits in first 2 volutions.

Spirotheca composed of tectum and fairly thin keriotheca.

REMARKS: Only one poorly preserved specimen of P. sp. B was found. P. sp. B resembles P. cf. P. kaerimizensis (Ozawa), but there is not sufficient data available to compare favorably.

OCCURRENCE: *P. sp. B* was collected from unit 22, 212 feet above the base of section 26. No other fusulinids were collected along with *P. sp. B*.

Repository: Brigham Young University Paleontology Collection 12024-580.

Parafusulina sp. C.
(Plate 1)

Shell large, cylindrical, slightly depressed in the medial area. Single specimen 13 mm. long and 3. 6 mm. wide. Poles broadly rounded.

Septa heavy and intensely fluted throughout the shell, forming irregular chamberlets.

Spirotheca fairly thick; composed of tectum and keriotheca.

REMARKS: Only one poorly preserved specimen of *Parafusulina sp. C* was observed. This form does not resemble any of the other species described from this area, and the specimen is not preserved well enough for other comparative studies. Therefore it has been called *P. sp. C.*

OCCURRENCE: *P. sp. C.* occurs in unit 20, 650 feet above the base of section 26. No other fusulinids were collected along with *P. sp. C.* Stratigraphically, *P. sp. C* occurs in Early Leonard rocks.

Repository: Brigham Young University Paleontology Collection 12024-579.

Parafusulina cf. P. sonoraensis Dunbar
(Plate 3, table 9)

Shell large, cylindrical fusiform with straight axis of coiling. Broadly rounded poles. Mature specimens contain 5 - 6 volutions. About 10. 2 mm. long, 4. mm. wide. Average form ratio is 1:2. 5. Average form ratio in first volution is 1:1. 8, in third volution 1:2. 1, and in fifth volution 1:2. 5.

Proloculus is large. Its outside diameter is 400 microns. Volution heights increase poleward from center.

Septa are thin, regularly and highly fluted, forming narrow chamberlets which reach to the top of the chambers. Average septal count for first to sixth volutions 13, 18, 22, 23, 31, and 35 respectively.

Spirotheca composed of tectum and fairly thin keriotheca. It is regular throughout the shell except for a slightly depressed medial area. Average spirothecal thickness for first to sixth volutions is 33, 35, 50, 65, 100, and 80 microns, respectively.

REMARKS: Parafusulina sonoraensis Dunbar has only been reported from Sonora, Mexico, but it is very similar to Parafusulina diabloensis Dunbar and Skinner of West Texas. The forms which I found are similar to P. sonoraensis Dunbar in shape of shell and fluting of septa, except my forms are smaller and have fewer volutions. P. sonoraensis Dunbar has 8 - 9 volutions and mine have 6 - 7 volutions. The species described here then, is compared with P. sonoraensis with question.

OCCURRENCE: P. cf. P. sonoraensis Dunbar occurs at two different horizons. It is found in unit 21, 590 feet above the base of section 26, and at the base of unit 15, 1840 feet above the base of section 26. In unit 21 it occurs alone, but is found with P. cf. P. kaerimizensis (Ozawa) in unit 15. This would indicate that P. cf. P. sonoraensis is Early and Medial Leonard in age.

Repository: Brigham Young University Paleontology Collection 12024-568, 587, 588, 589, 596.

Parafusulina cf. P. ? turgida Thompson and Wheeler
(Plate 4, table 10)

Shell large, inflated fusiform with regular axis of coiling and pointed poles. Mature specimens of 5 - 6 volutions. 8.6 - 11.0 mm. long, 4.6 - 4.8 mm. wide. Form ratio 1:1.9 - 1:2.3. Lateral slopes become concave in second to sixth volutions. Average form ratio is 1:2.2. Form ratio of first volution about 1:1.8; of third 1:2.2; of fifth 1:2.1; of sixth 1:2.2.

Proloculus is large, outside diameter being 333 - 433 microns in size. Shell throughout all growth stages loosely coiled.

Septal count of first to fifth volutions of one specimen 14, 26, 28, 32, 40, 41 mm. Other characteristics: septa fluted regularly

and highly throughout, and form high narrow chamberlets reaching to the top of the chambers. Fluting is slightly heavier in axial region.

Neither tunnel nor chomata are observed.

Spirotheca is composed of tectum and thick keriotheca with coarse alveoli. Average thickness of spirotheca in first to sixth volutions in mm. is: 34, 43, 73, 115, 138, 113 microns.

REMARKS: Thompson and Wheeler question the generic affinities of this species because of its heavy spirotheca and inflated median section which are characteristics of the genus Schwagerina, but because of the well developed cuneculi and single tunnel, they have called it a Parafusulina. The forms described in this work, however, are somewhat smaller than those described by Thompson and Wheeler from the McCloud limestone of California, but they appear to be conspecific.

OCCURRENCE: P. cf. P. ? turgida Thompson and Wheeler was found in unit 19, 689 feet from the base of section 26. It appears to be an early Leonard form in this section. P. cf. P. ? turgida Thompson and Wheeler occurs with Pseudofusulinella occidentalis (Thompson and Wheeler), Parafusulina cf. P. sonoraensis Dunbar and Skinner, and Parafusulina sp. C.

Repository: Brigham Young University Paleontology Collection, 12024-569, 570, 571.

Parafusulina kaerimizensis (Ozawa)
(Plate 3, table 7)

Shell large, elongate, cylindrical fusiform. Bluntly pointed poles. Median section of shell straight to slightly depressed. Straight axis of coiling. Mature specimens contain 5 - 6 volutions; are 11.6 - 12.4 mm. long and are 3.2 - 3.6 mm. wide. Form ratio 1:3.2 - 1:3.8. Average form ratio about 1:3.5. Average form ratio of first volution is about 1:1.8, of third volution 1:3., of fifth volution 1:3.7.

Proloculus is moderately large. Outside diameter 300 - 366 microns. Average outside diameter 333 microns for 2 specimens. Shell expands uniformly.

Septal count of first to fifth volutions in one specimen is 11, 17, 25, 32, 28 mm. respectively. The septa are highly fluted throughout the shell. They form narrow chamberlets which reach the tops of the chambers throughout the length of the shell.

Tunnel is low. Average tunnel angles in first to fourth volutions are 30°, 32°, 44°, 43°. Chomata is not observed. Average spirothecal thickness in first to sixth volutions is 29, 37, 39, 68, 86, 85 microns respectively. The spirotheca is composed of upper tectum and moderately thick keriotheca. Heavy secondary deposits occur along the axis of the first and second volutions.

REMARKS: Parafusulina kaerimizensis (Ozawa) is a very common species found in the Middle Permian of Japan. The forms here described are compared with those described from the Akiyoshi limestone group of Japan (Toriyama, 1958). The forms referred to P. kaerimizensis (Ozawa) are slightly smaller in length and width than those described by Toriyama, however there are sufficient similarities to refer the Cache Creek forms to this species.

OCCURRENCE: P. cf. P. kaerimizensis (Ozawa) is a Leonard form which is found at the base of unit 15, 960 feet from the bottom of the section, and 500 feet into the Leonard. This species occurs with P. cf. P. sonoraensis Dunbar and Skinner. Within unit 15 there is a sharp faunal break as P. cf. P. kaerimizensis (Ozawa) and P. cf. P. sonoraensis Dunbar and Skinner disappear, and Pseudofusulinella cf. P. montis (Thompson and Wheeler) appears.

Repository: Brigham Young University Paleontology Collection, 12024-565, 566.

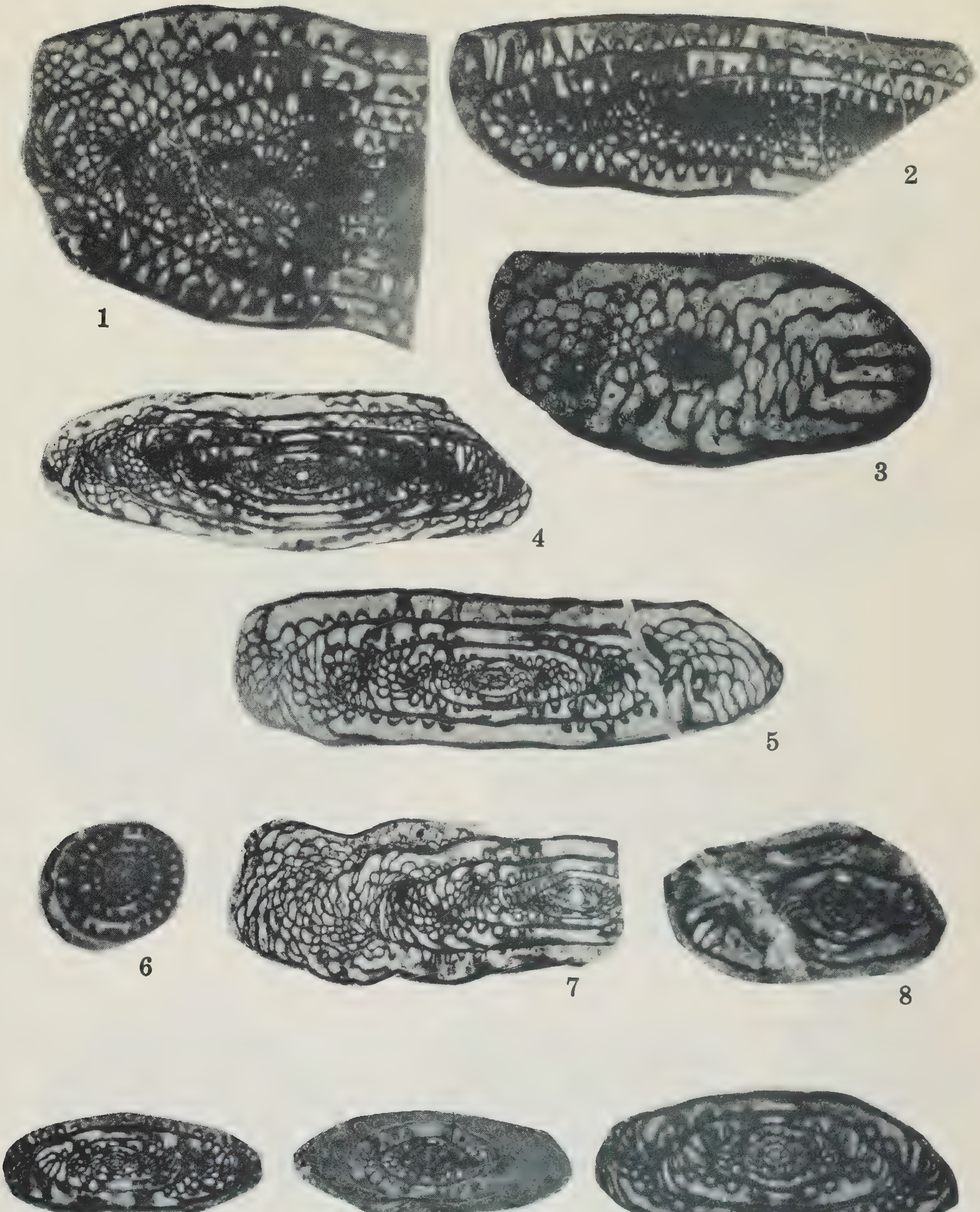
Parafusulina cf. P. ? calx Thompson and Wheeler
(Plate 4, table 8)

Shell large, elongate, cylindrical fusiform. Sharply pointed poles and low lateral slopes. Straight axis of coiling. Mature specimen contains 5 - 6 volutions. Fourth, fifth, and sixth volutions are slightly depressed in their medial areas; 10.4 mm. long and 3.4 mm. wide. Form ratio of mature specimen is 1:3.2. Lateral slopes have slight tendency to become concave at fifth and sixth volutions. Form ratio of first volution is 1:1.6, of third 1:2.3, of fifth 1:2.6.

EXPLANATION OF PLATE I

Plate 1. - SCHUBERTELLA, SCHWAGERINA, AND PARAFUSULINA

PLATE I

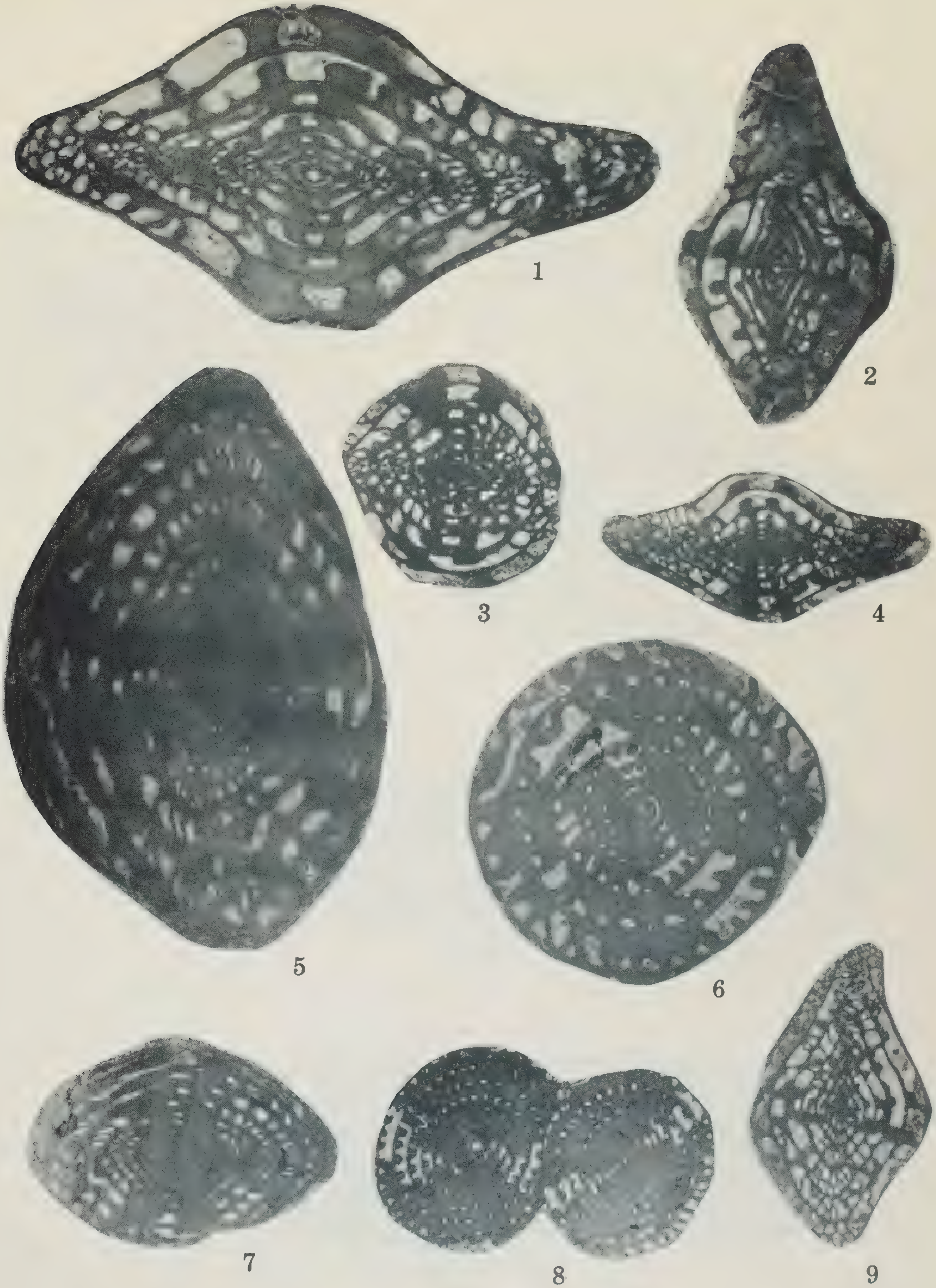


EXPLANATION OF PLATE II

Plate 2. - PSEUDOFUSULINELLA

Figure		Page
1, 2, 4, 6, 9.	*Pseudofusulinella occidentalis* (Thompson and Wheeler). Axial section times 20 (1, 2). Sagittal section times 20 (6). Axial sections time 10 (4, 9). Repository: Brigham Young University 12023-584; and 12024-541, 539, 545, 540	21
3.	*Pseudofusulinella sp. A.* Axial section times 10. Repository: Brigham Young University 12024-585	19
5, 7, 8.	*Pseudofusulinella cf. P. montis* (Thompson and Wheeler). Axial section times 20 (5). Axial section times 10 (7), sagittal section times 10 (8). Repository: Brigham Young University 12024-586, 586, 548	19

PLATE II

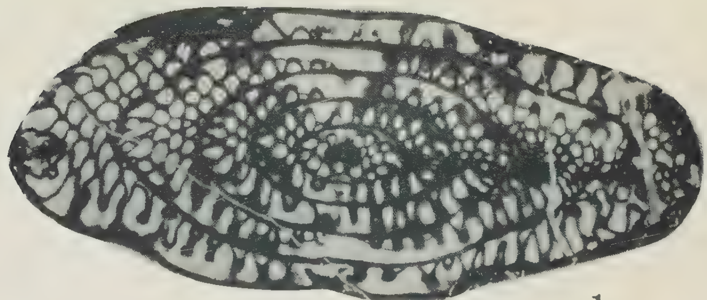


EXPLANATION OF PLATE III

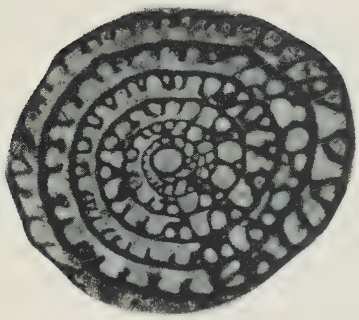
Plate 3. - PARAFUSULINA

Figure		Page
1, 2, 3, 4, 5.	*Parafusulina cf. P. sonoraensis* Dunbar. Axial sections times 10 (1, 3, 5). Sagittal sections times 10 (2, 4). Repository: Brigham Young University 12024-589, 587, 568, 588, none	26
6.	*Parafusulina cf. P. kaerimizensis* (Ozawa). Axial section times 10. Repository: Brigham Young University 12024-566	28

PLATE III

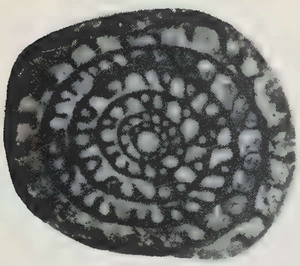


1

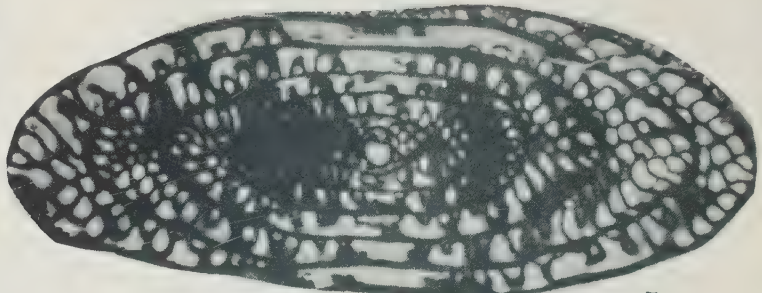


2

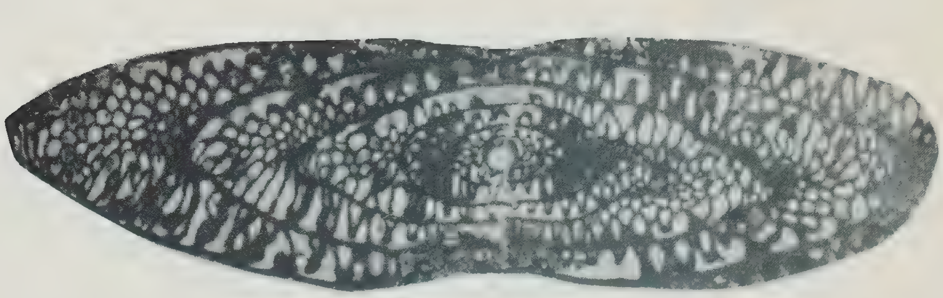
3



4



5



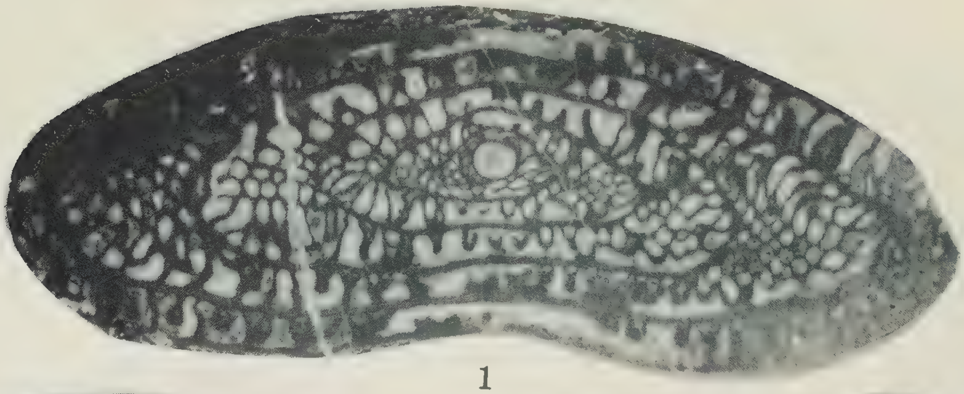
6

EXPLANATION OF PLATE IV

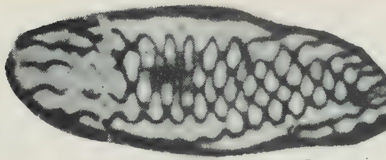
Plate 4. - PARAFUSULINA

Figure		Page
1-4, 6.	*Parafusulina n. sp. A.* Nearly axial section times 10 (1). Axial section times 10 (6). Tangential section showing cuneculi (2). Sagittal sections times 10 (3, 4). Repository: Brigham Young University 12023-590, 591, 578, 592, 574	40
5.	*Parafusulina cf. P. ? turgida* Thompson and Wheeler. Axial section times 10. Repository: Brigham Young University 12024-569	27
7.	*Parafusulina cf. P. ? calx* Thompson and Wheeler. Axial times 10. Repository: Brigham Young University 12024-567	29

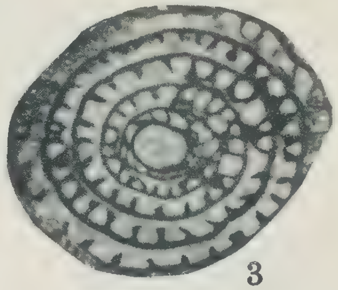
PLATE IV



1



2

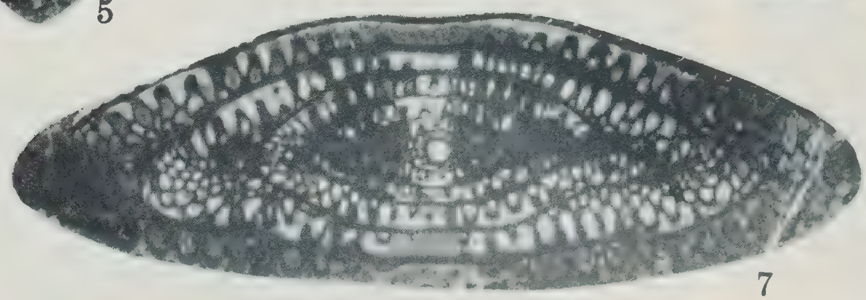


3

4

5

6



7

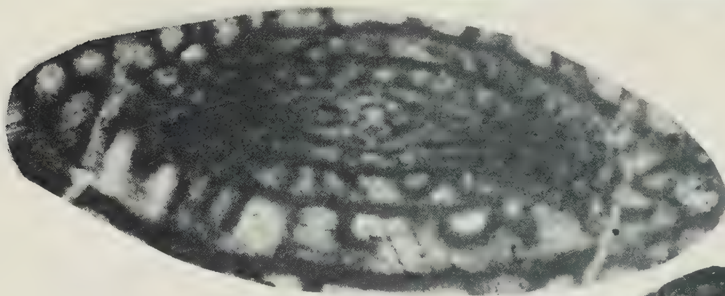
EXPLANATION OF PLATE V

Plate 5. - PARAFUSULINA

Figure		Page
1-5.	*Parafusulina* *n. sp. B.* Nearly axial times 10 (1). Tangential times 10 (5). Sagittal times 10 (3). Axial and sagittal view of microspheric proloculus times 50 (2, 4). Repository: Brigham Young University 12023-593, 594, 564, 564, 561	42

PLATE V

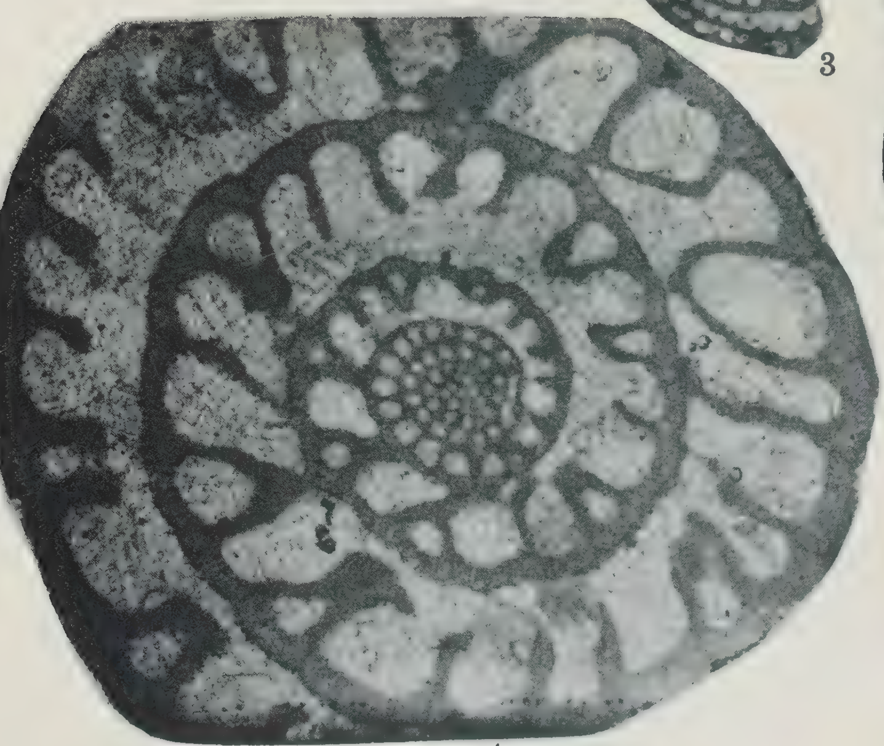
1



2

3

5



4

Proloculus large, its outside diameter 367 microns. Heights of volutions increase slightly poleward from center of shell. Shell expands uniformly.

Septa are highly and regularly fluted, and form narrow chamberlets that reach to the top of the chambers.

Tunnel low and medium wide. Tunnel angles for the first to fifth volutions are 48°, --, 30°, 30°, and 33°. Chomata not observed. Some secondary deposits in axial regions of first two volutions.

Spirotheca thick. In first to sixth volutions of a typical specimen they measure 20, 30, 43, 80, 100, 70 microns, respectively.

REMARKS: *Parafusulina? calx* Thompson and Wheeler resembles *Schwagerina (?) hessensis* Dunbar and Skinner, from the lower part of the Leonard formation of Texas. The over all shape and the thick spirotheca are characteristics of the subfamily Schwagerininae. *Parafusulina? calx* Thompson and Wheeler is included in the genus *Parafusulina* only because it possesses cuneculi. The Cache Creek forms are somewhat smaller than those described by Thompson and Wheeler from the McCloud limestone, but shape, fluting, and spirothecal thickness indicate that it is probably *Parafusulina? calx* Thompson and Wheeler.

OCCURRENCE: *Parafusulina cf. P. ? calx* Thompson and Wheeler was found in unit 9, 1300 feet above the base of section 18. By the fault relationship I judged this to be equal to approximately 1200 feet above the base of section 26. At the spot this collection was made the limestone is a coquina of *P. cf. P. ? calx* Thompson and Wheeler. No other fusulinids were found with this species.

Repository: Brigham Young University Paleontology Collection, 12023-567.

Parafusulina n. sp. A
(Plate 4, table 11)

Shell large, elongate, and cylindrical; with broadly curving axis of coiling, rounded poles. Mature specimens of 6 - 7 volutions; 13.4 to 20. mm. long, 3.6 to 3.8 mm. wide. Form ratio of mature specimens 1:3.5 - 1:3.8. Average form ratio 1:3.6 for 3 typical

specimens. Form ratio of first to sixth volutions of a typical specimen 1:1.1, 1:1.6, 1:2.5, 1:2.6, 1:3.0, 1:3.3, 1:3.5, respectively.

Proloculus large; outside diameter being 500 to 566 microns. Average outside diameter of proloculus is about 533 microns. Proloculus in some specimens is irregular.

Average septal count for four specimens from first to fifth volutions respectively is 11, 21, 24, 30, 33. Septa are relatively thin and highly fluted. Fluting is somewhat irregular, forming irregular chamberlets throughout the shell. Cuneculi are well developed in the third and fourth volutions.

Tunnel is low and broad. Average tunnel angle for the first to fifth volutions 32°, 34°, 48°, 47°, and 50°. Tunnel angle increases at a constant rate. No chomata present.

Spirotheca thin and somewhat irregular. Average thickness for first to seventh volutions 40, 54, 83, 87, 95, 133, 100 microns respectively.

REMARKS: Parafusulina n. sp. A resembles Parafusulina fountaini Dunbar and Skinner and Parafusulina bakeri Dunbar and Skinner, from the Guadalupe mountain of West Texas. P. n. sp. A, however, has more irregular fluting and spirotheca. It is hazardous to correlate West Texas species with this isolated province of the West Coast. Some of the sections measured were slightly off centered, but this did not seriously hinder the accuracy of the measurements.

OCCURRENCE: Parafusulina n. sp. A was collected from unit 11, 1800 feet from the base of section 18. Their stratigraphic position in section 26 is interpreted to be approximately 1300 feet above the base. This would put Parafusulina n. sp. A in the high Leonard. No other fusulinids were found with this species.

Repository: Brigham Young University Paleontology Collection, 12023-572, 573, 574, 575, 576, 577, 578, 590, 591, 592.

Parafusulina n. sp. B
(Plate 5, table 6)

Shell large, highly elongate and cylindrical; somewhat undulating. Slightly curved axis of coiling; rounded poles. Mature specimens of 6 - 7 volutions, 14. - 18.6 mm. long, 4.2 - 4. 8 mm. wide. Form ratio of mature specimens 1:3.4 - 1:3.9. Average form ratio 1:3.7 for three typical specimens. Form ration of first to sixth volutions of a typical specimen 1:3.2, 1:3.8, 1:3.2, 1:2.6, 1:2.5, 1:3.4, respectively.

Proloculus microscopic, outside diameter 33 microns.

Septa are of medium thickness, highly fluted, forming narrow irregular chamberlets to the top of the chambers. Average septal count for second to seventh volutions 14, 20, 20, 23, 29, and 35, respectively. Cuniculi are very small and difficult to find, but are present in some of the medial volutions.

Neither tunnel nor chomata appears to be present.

Spirotheca moderately thick. Thickness in first to seventh volutions 33, 50, 82, 122, 118, 123, 133 microns, respectively. Beginning at second or third volution, most specimens have undulating spirotheca.

REMARKS: Parafusulina n. sp. B does not resemble any other Parafusuline. It may be that this form is a microspheric form of some other species, but it is not a product of alternation of generation because there are no megalospheric forms present.

OCCURRENCE: Parafusulina n. sp. B occurs at the top of section 18, 2900 feet from the base of the section. Their stratigraphic position in section 26 is interpreted to be 1490 feet from the base, which is high Leonard in age. P. n. sp. B occurs with Pseudofusulinella occidentalis (Thompson & Wheeler), and Schwagerina cf. S. modica Thompson and Hazzard.

Repository: Brigham Young University Paleontology Collection 12023-561, 562, 563, 564, 593, 594.

Table 1. Table of Measurements (in Millimeters) of Pseudofusulinella occidentalis (THOMPSON AND WHEELER)

Loc.	Specimen	Pl.	$\frac{1}{2}$L.	$\frac{1}{2}$W.	R.
26-27	539	2	2.31	1.27	1.84
26-19	540	2	2.54	1.425	
26-23	541		2.0	1.02	1.96
26-27	542	2	--	--	--
26-23	543		1.90	.850	2.24
26-22	544		1.87	.90	2.00

Loc.	Specimen	Prol. (Mic)	Radius vector 1	2	3
26-27	539	40	.05	.075	.14
26-19	540		.07	.105	.16
26-23	541	133	.119	.185	.285
26-27	542	90	.09	.115	.140
26-23	543	133	.095	.150	.240
26-22	544	116	.090	.115	.170

Loc.	Specimen	Radius vector 4	5	6	7	8	9
26-27	539	.205	.335	.44	.675	.960	1.22
26-19	540	.275	.485	.685	.960	1.21	1.44
26-23	541	.485	.615	.845	1.02		
26-27	542	.22	.31	.450	.72		
26-23	543	.360	.504	.70	.850		
26-22	544	.245	.365	.480	.70		

Loc.	Specimen	Thickness of spirotheca (Mic.) 1	2	3	4	5	6
26-19	540			40.	53.		67.
26-27	545	16.5	33.	43.	67.	57.	73.
26-23	546	26.	24.	33.	40.	17.	32.
26-27	542	20.	27.	33.	35.	46.	56.
26-23	543	10.	17.	20.	20.	25.	30.
26-22	544	10.	17.	20.	33.	--	37.

Loc.	Specimen	Thickness of spirotheca (Mic.) 7	8	9
26-19	540	60		
26-27	545	100	67	58
26-23	546	37		
26-27	542	60		
26-23	543	(wall may be weathered)		
26-22	544	20		

Loc.	Specimen	Ratio of Hl./Rv. 1	2	3	4	5
26-27	539	1.5	2.0	2.14	2.2	2.0
26-19	540	1.57	2.61	2.44	2.3	2.0
26-23	541	1.61	1.86	1.95	1.42	1.55
26-27	542	1.3	2.03	2.4	2.6	2.7
26-23	543	1.75	1.65	1.66	1.66	1.84
26-22	544	1.11	1.40	1.74	2.02	2.1

Loc.	Specimen	Ratio of Hl./Rv. 6	7	8	9
26-27	539	1.92	1.8	1.82	1.9
26-19	540	1.85	1.85	2.1	2.0
26-23	541	1.62	1.96		
26-27	542	---	---		
26-23	543	1.45	2.24		
26-22	544	2.3	2.02		

Loc.	Specimen	Tunnel angle 1	2	3	4
26-27	539	10	8	12	13
26-19	540	10	8	15	17
26-23	541	17	21	23	23
26-27	542	15	16	16	20
26-23	543	22	23	25	27
26-22	544	15	24	21	17

Loc.	Specimen	Tunnel angle 5	6	7	8
26-27	539	15	15	18	21
26-19	540	18	18	21	
26-23	541	22	25		
26-27	542	22	22		
26-23	543	28	30		
26-22	544	18	20	20	

Loc.	Specimen	Septal count 1	2	3	4
26-27	545	9	16	18	22

Loc.	Specimen	5	6	7	8
26-27	545	24	26	29	31

Table 2. Table of Measurements (in Millimeters) of Pseudofusulinella cf. P. montis (THOMPSON AND WHEELER)

Loc.	Specimen	Pl.	$\frac{1}{2}$L.	$\frac{1}{2}$W.	R.	Prol. (Mic)
26-15	547			1.85		
26-15	548	2		1.75		
26-15	548			1.50		
26-15	549			1.65		
26-15	550		2.45	1.82	1.43	200
26-15	551		2.32	1.57		
26-15	552		1.54	1.25		166

Loc.	Specimen	Radius vector					
		1	2	3	4	5	6
26-15	550	.16	.235	.335	.450	.600	.675
26-15	551	.10	.145	.24	.380	.520	.710
26-15	552	.140	.200	.275	.355	.515	.630

Loc.	Specimen	Radius vector					
		7	8	9	10	11	12
26-15	550	.750	.900	1.09	1.35	1.60	.675
26-15	551	.880	1.1	1.31	1.59		
26-15	552	.805	1.01	1.25			

Loc.	Specimen	Thickness of spirotheca (Mic.)					
		1	2	3	4	5	6
26-15	550	20	33	20	40	66	66
26-15	548	--	--	--	43	50	57

Loc.	Specimen	Thickness of spirotheca (Mic.)					
		7	8	9	10	11	12
26-15	550	70	72	72	66	66	--
26-15	548	63	66				

Loc.	Specimen	Ratio of Hl. /Rv.					
		1	2	3	4	5	6
26-15	550	1.094	1.063	1.06	1.055	1.00	1.185
26-15	551	2.15	2.76	2.25	1.97	1.89	1.63
26-15	552	1.27	1.30	1.27	1.27	1.17	1.27

Loc.	Specimen	Ratio of Hl. /Rv.					
		7	8	9	10	11	12
26-15	550	1.33	1.39	1.37	1.33	1.345	1.345
26-15	551	1.61	1.51	1.59	1.48		
26-15	552	1.26	1.20	1.26	-		

Loc.	Specimen	Tunnel angle					
		1	2	3	4	5	6
26-15	550	10	15	10	8	8	5
26-15	551	16	18	13	15	12	11
26-15	552	7	11	11	10	10	10

Loc.	Specimen	Tunnel angle					
		7	8	9	10	11	12
26-15	550	10	8	10	13	15	12
26-15	551	11	11	12			
26-15	552	9	9	10			

Loc.	Specimen	Septal count						
		1	2	3	4	5	6	7
26-15	548	15	20	19	23	28	35	37
26-15	552	9	15	17	17	23	28	29

Table 3. Table of Measurements (in Millimeters) of Schwagerina cf. S. modica THOMPSON & HAZZARD

Loc.	Specimen	Pl.	$\frac{1}{2}$L.	$\frac{1}{2}$W.	R.	Prol. (Mic)
26-27L	553	1	1.67	.60	2.8	167.
26-27L	553	1	1.50	.60	2.5	107.
18-20	554	1	2.2	.76		100.
26-24	555		1.67	.66		100.

Radius vector

Loc.	Specimen	1	2	3	4	5	6
26-27L	553	.110	.20	.30	.40	.60	
26-27L	553	.107	.20	.30	.466	.60	
18-20	554	.083	.133	.21	.333	.465	.76
26-24	555	.073	.133	.234	.333	.468	.66

Thickness of spirotheca (Mic)

Loc.	Specimen	1	2	3	4	5	6
26-27L	553	7	10	30	33	47	
26-27L	553	10	23	35	57	35	
18-20	554	16	23	37	33	66	
26-24	555	16	30	50	40	40	
26-27L	556	16.6	24	35	37	--	

Ratio of Hl./Rv.

Loc.	Specimen	1	2	3	4	5	6
26-27L	553	1.5	1.66	1.66	2.5	2.8	
26-27L	553	1.21	1.66	1.87	2.15	2.5	
18-20	554	1.60	1.75	2.3	2.20	2.3	2.9
26-24	555	1.37	1.63	2.06	2.02	2.67	2.53

Tunnel angle

Loc.	Specimen	1	2	3	4	5	6
26-27L	553		25	31	40		
26-27L	553	30	30	31	57		
18-20	554	30	30	30	63		
26-24	555	26	23	40	66		

Septal count

Loc.	Specimen	1	2	3	4	5	6
26-27L	556 (Sagg.)	7	13	15	17		

Table 4. Table of Measurements (in Millimeters) of
<u>Parafusulina</u> <u>sp</u>. <u>A</u>

Loc.	Specimen	Pl.	$\frac{1}{2}$L.	$\frac{1}{2}$W.	R.	Prol. (Mic)
26-27	557	1	4.00	1.33	3.0	200
26-27	558		4.50	1.22		

Radius vector

Loc.	Specimen	1	2	3	4	5	6	7
26-27	557	.133	.200	.366	.533	.73	.92	1.33
26-27	558	.133	.20	.300	.450	.60	.833	1.22

Thickness of spirotheca (Mic.)

Loc.	Specimen	1	2	3	4	5	6	7
26-27	557	33	53	47	67	65	80	130
26-27	558	13	27	53	50	40	72	100

Ratio of Hl. /Rv.

Loc.	Specimen	1	2	3	4	5	6	7
26-27	557	2.56	3.3	3.3	4.4	---	4.4	3.0
26-27	558	1.50	1.83	2.1	2.7	3.3	3.4	3.7

Tunnel angle

Loc.	Specimen	1	2	3	4	5	6	7
26-27	557	40	40	46	60	61		
26-27	558	52	32	36	55	59		

Septal count

Loc.	Specimen	1	2	3	4	5	6	7
26-27	559	9	13	18	20	23	25	

Table 5. Table of Measurements (in Millimeters) of Parafusulina gracilis (MEEK)

Loc.	Specimen	Pl.	$\frac{1}{2}$L.	$\frac{1}{2}$W.	R.	Prol. (Mic)
26-27	560		3.6	.866	4.16	
26-27	560		4.0	1.0	4.0	100
26-27	556	1	5.33	1.33	4.0	273

Radius vector

Loc.	Specimen	1	2	3	4	5	6	7
26-27	560	.153	.256	.397	.573	.866		
26-27	560	.133	.260	.326	.466	.700	1.0	
26-27	556	.20	.32	.453	.666	1.00	1.33	

Thickness of spirotheca (Mic)

Loc.	Specimen	1	2	3	4	5	6	7
26-27	560	33	47	60	80	70		
26-27	560	16	35	37	60	80	---	
26-27	556	16	30	35	60	100	72	

Ratio of Hl. /Rv.

Loc.	Specimen	1	2	3	4	5	6	7
26-27	560	1.74	2.34	2.66	4.2	4.15		
26-27	560	1.92	1.73	2.87	3.56	4.0		

Tunnel angle

Loc.	Specimen	1	2	3	4	5	6	7
26-27	560	42	54	74	---	---		
26-27	560	41	35	42	---	---	---	
26-27	556	32	45	66	---	---		

Table 6. Table of Measurements (in Millimeters) of
Parafusulina n. sp. B

Loc.	Specimen	Pl.	$\frac{1}{2}$L.	$\frac{1}{2}$W.	R.	Prol. (Mic)
18-20	561	5	8.66	2.24	3.9	33
18-20	562		9.30	2.40	3.9	Not shown
18-20	563		7.0	2.06	3.4	Not shown

					Radius vector			
Loc.	Specimen	1	2	3	4	5	6	7
18-20	561	---	---	---	.766	1.365	1.85	2.24
18-20	562	---	.2	.533	1.03	1.46	1.93	2.40
18-20	563	.10	.216	.366	.70	1.165	1.70	2.06

					Thickness of spirotheca (Mic)			
Loc.	Specimen	1	2	3	4	5	6	7
18-20	561	---	---	100	100	120	125	
18-20	562	33	50	100	117	133	135	
18-20	563	---	40	45	50	100	110	133

					Ratio of Hl./Rv.			
Loc.	Specimen	1	2	3	4	5	6	7
18-20	561				3.3	2.8	3.8	3.9
18-20	562		3.65	3.1	2.4	2.7	3.65	3.9
18-20	563	2.6	3.24	3.8	3.15	2.6	2.5	3.4

					Septal count			
Loc.	Specimen	1	2	3	4	5	6	7
18-20	564		14	20	20	23	29	35

Table 7. Table of Measurements (in Millimeters) of
Parafusulina cf. P. kaerimizensis (Ozawa)

Loc.	Specimen	Pl.	½L.	½W.	R.	Prol. (Mic)
26-19	565		5.8	1.8	3.2	300
26-15	566	3	6.2	1.6	3.8	366

Radius vector

Loc.	Specimen	1	2	3	4	5	6	7
26-19	565	.216	.400	.633	.964	1.02	1.76	
26-15	566	.285	.400	.666	.966	1.33	1.6	

Thickness of spirotheca (Mic)

Loc.	Specimen	1	2	3	4	5	6	7
26-19	565	33	37	47	70	100	105	
26-15	566	20	40	33	67	87	70	

Ratio of Hl./Rv.

Loc.	Specimen	1	2	3	4	5	6	7
26-19	565	2.3	2.0	3.2	3.4	4.4	3.3	
26-15	566	1.15	2.08	2.7	2.8	3.0	3.8	

Tunnel angle

Loc.	Specimen	1	2	3	4	5	6	7
26-19	565	39	32	40	35			
26-15	566	21	--	48	51			

Table 8. Table of Measurements (in Millimeters) of Parafusulina cf. P. ? calx THOMPSON AND WHEELER

Loc.	Specimen	Pl.	$\frac{1}{2}$L.	$\frac{1}{2}$W.	R.	Prol(Mic)
18-9	567	4	5.33	1.67		367

Radius vector

Loc.	Specimen	1	2	3	4	5	6	7
18-9	567	.286	.466	.682	1.02	1.40	1.67	

Thickness of spirotheca (Mic)

Loc.	Specimen	1	2	3	4	5	6	7
18-9	567	20	30	43	80	100	70	

Tunnel angle

Loc.	Specimen	1	2	3	4	5	6	7
18-9	567	48	--	30	30	33		

Table 9. Table of Measurements (in Millimeters) of Parafusulina cf. P. sonoraensis DUNBAR

Loc.	Specimen	Pl.	$\frac{1}{2}$L.	$\frac{1}{2}$W.	R.	Prol(Mic)
26-15B	568	3	5.1	2.0	2.5	400

Radius vector

Loc.	Specimen	1	2	3	4	5	6	7
26-15B	568	.40	.666	1.00	1.27	1.66	2.0	

Thickness of spirotheca (Mic)

Loc.	Specimen	1	2	3	4	5	6	7
26-15B	568	33	35	50	65	100	80	

Ratio of Hl. /Rv.

Loc.	Specimen	1	2	3	4	5	6	7
26-15B	568	1.8	2.1	2.13	2.2	2.5	2.5	

Table 10. Table of Measurements (in Millimeters) of Parafusulina cf. P. ? turgida THOMPSON AND WHEELER

Loc.	Specimen	Pl.	½L.	½W.	R.	Prol. (Mic)
26-19	569	.4	4.32	2.33	1.85	347
26-19	570		5.50	2.4	2.3	433
26-19	569		5.33	2.33		333

Radius vector

Loc.	Specimen	1	2	3	4	5	6	7
26-19	569	.315	.632	1.05	1.44	1.93	2.33	
26-19	570	.533	.570	.966	1.43	1.90	2.40	
26-19	569	.223	.50	.90	1.40	1.86	2.33	

Thickness of spirotheca (Mic)

Loc.	Specimen	1	2	3	4	5	6	7
26-19	569	33	40	54	76	133	100	
26-19	570	33	40	66	100	136	125	
26-19	569	37	60	100	170	145		

Ratio of Hl. /Rv.

Loc.	Specimen	1	2	3	4	5	6	7
26-19	569	1.59	1.85	1.06	1.53	1.73	1.85	
26-19	570	2.27	2.91	2.6	2.3	2.2	2.3	
26-19	569	1.50	2.4	2.95	2.4	2.4	2.3	

Tunnel angle

Loc.	Specimen	1	2	3	4	5	6	7
26-19	569							
26-19	570							
26-19	569							

Septal count

Loc.	Specimen	1	2	3	4	5	6	7
26-19	571	14	26	28	32	40	41	

Table 11. Table of Measurements (in Millimeters) of
Parafusulina n. sp. A

Loc.	Specimen	Pl.	$\frac{1}{2}$L.	$\frac{1}{2}$W.	R.	Prol. (Mic)
18-11	572		10.1	2.86	3.5	566
18-11	573		7.7	2.14	3.6	533
18-11	574	4	6.66	1.76	3.75	500

Radius vector

Loc.	Specimen	1	2	3	4	5	6	7
18-11	572	.6	.80	1.07	1.53	2.0	2.46	2.86
18-11	573	.5	.833	1.265	1.73	2.14		
18-11	574	.366	.53	.80	1.13	1.43	1.76	

Thickness of spirotheca (Mic.)

Loc.	Specimen	1	2	3	4	5	6	7
18-11	572	43	40	66	73	116	133	100
18-11	573	37	67	100	100	73		

Ratio of Hl./Rv.

Loc.	Specimen	1	2	3	4	5	6	7
18-11	572	1.1	1.6	2.5	2.6	3.0	3.35	3.5
18-11	573	1.33	1.6	2.4	3.08	3.6		
18-11	574	1.76	3.3	3.5	3.7	3.75		

Tunnel angle

Loc.	Specimen	1	2	3	4	5	6	7
18-11	572	28	26	---	33	50		
18-11	573	36	41	48	60			

Septal count

Loc.	Specimen	1	2	3	4	5	6	7
18-11	575	11	23	27	31			
18-11	576	14	20	24	28			
18-11	577	10	17	24	32	34		
18-11	578	--	21	23	30	32		

REFERENCES CITED

Armstrong, T. E., 1949, Fort St. James Map-area, Cassiar and Coast Districts, British Columbia; Geol. Sur., Canada, Mem. 252.

Dawson, G. M., 1878, Report on Explorations in British Columbia, chiefly in the Basins of the Black Water, Salmon and Hechacco Rivers, and on Francois Lake; Geol. Sur., Canada, Rept. of Prog. 1876-77.

Duffell, S., and McTaggart, K. C., 1952, Ashcroft Map-area, British Columbia; Geol. Sur., Canada, Mem. 262.

Dunbar, C. O., 1933, Newschwagerina in the Permian Faunas of British Columbia; Trans. Roy. Soc., Canada, 3rd ser., vol. 26, sec. IV, pp. 45-50.

________, 1939, Permian Fusulines from Sonora; Geol. Soc., America, vol. 50, pp. 1745-1760.

Hoadley, J. W., 1953, Geological Sur., Canada, Mem. 272.

Jones, A. G., 1959, Vernon Map-area, British Columbia; Geol. Sur., Canada, Mem. 296.

Kerr, F. A., 1948, Lower Stikine and Western Iskat River Areas, British Columbia; Geol. Sur., Canada, Mem. 246.

McLearn, F. H., and Kindle, E. D., 1950, Geol. Sur., Canada, Mem. 259.

Roots, E. F., 1954, Geol. Sur., Canada, Mem. 274.

Selwyn, A. R. C., 1872, Jour. and Report of Preliminary Explorations in British Columbia; Geol. Sur., Canada, Rept. of Prog. 1871-72, pp. 16-72.

Thompson, M. L., Pitrat, C. W., and Sanderson, G. A., 1953, Primitive Cache Creek Fusulinids from Central British Columbia; Jour. Paleo., vol. 27, pp. 545-552.

________, and Verville, G. J., 1950, Cache Creek Fusulinids from Kamloops, British Columbia; Contr. Cush. Found. Foram. Research, vol. 1, pp. 67-70.

________, and Wheeler, H. E., 1942, Permian Fusulinids from British Columbia, Washington, and Oregon; Jour. Paleo., vol. 16, no. 6, pp. 700-711.

________, and Wheeler, H. E., and Danner, W. R., 1950, Middle and Upper Permian Fusulinids of Washington and British Columbia; Cush. Found. Foram. Research, vol. 1, pp. 40-63.

________, and Wheeler, H. E., and Hazzard, J. C., 1956, Permian Fusulinids of California; Geol. Soc., America, Mem. 17.

Toriyama, Ryuzo, 1958, Geology of Akiyoshi, Part III, Fusulinids of Akiyoshi; Mem. of the Faculty of Science, Kyushu University, Series D, Geology, vol. VII.

ABUNDANCE OF FUSULINID OCCURRENCE

	Very Abundant	Abundant	Common	Rare	Single Specimen
Parafusulina n. sp. B			X		
Parafusulina n. sp. A	X				
Parafusulina cf. P. ? calx				X	
Parafusulina kaerimizensis				X	
Parafusulina cf. P. ? turgida			X		
Parafusulina sp. C					X
Parafusulina cf. P. sonoraensis			X		
Parafusulina sp. B					X
Parafusulina sp. A			X		
Parafusulina gracilis	X				
Schwagerina cf. S. modica			X		
Pseudofusulinella occidentalis		X			
Pseudofusulinella cf. P. montis		X			
Pseudofusulinella sp. A		abundant, but silicified.			
Schubertella kingi				X	

Scud River Upper Section
(Sec. 18)

Unit No.	Description	Thickness in feet	Feet above base
20	Limestone: very dark gray, weathers medium gray to light gray. Medium bedded siliceous unit grades from unit 19; break is made where Caninia appears; unit 20 then is faulted and swings up in juxtaposition to unit 19 with a change of strike offset within unit 20.	168	2750
19	Limestone and chert interbedded as in unit 10, becomes less cherty at top of unit. Siliceous small productids; some small chert blobs become thicker in bedding then return to a medium bedded chert	180	2570
18	Limestone: very dark gray-brown, weathers medium gray-brown. Thick bedding - massive, fine to medium grained bryozoan coquina at base of unit; some fusulinids, productids. Unit 18 faulted at base	64	2506
17	Limestone and chert interbedding: Limestone tuffaceous, chert light yellow and white moderately bedded. Limestone grades to dark gray and finely grained crystalline at top. Caninia (scarce), productids.	44	2462
16	Limestone tuffaceous, medium to coarse grained, medium, dark brown, and green-gray; weathers alternate gray-maroon and green-gray. Bottom of unit has prolific bryozoans and horn corals. Thick massive bedding	74	2388
15	Snow covered.	301	2087
14	Chert and limestone interbedded as in unit 10. Top of unit becomes less cherty.	104	1983

Unit No.	Description	Thickness in feet	Feet above base
13	Limestone as in the base of unit 11. Fusulinids coquina. Farther down the hill is a bryozoan coquina	93	1890
12	Limestone and chert interbedded as in unit 10, only much thinner	86	1804
11	Limestone: very dark gray-brown, very fine grained, weathers dirty gray-brown. Bryozoan coquina at top of unit; fusulinid coquina at base. This unit may be a repetition of unit 9. Some spotty brachiopod coquina	202	1602
10	Limestone and chert interbedded. Limestone predominant with 1'-2' beds. Chert 8"-10" beds, light medium gray, very fine grained crystalline. Chert weathers light yellow and white	293	1309
9	Limestone: dirty gray brown, fine to medium grained fossil hash near base of unit. Ramous bryozoans predominant; few fusulinids. Near top limestone becomes fusulinid hash. Some productid brachiopods and crinoids. Limestone medium bedding (siliceous) breaks into jagged blocks 8" x 5". Bottom 50' covered by snow.	155	1154
8	Limestone, dolomite, and chert interbedded. Limestone predominant, siliceous medium grained, very dark gray, weathers medium gray-brown. Dolomite very finely crystalline, weathers light cream. Black chert in blobs and 4"-8" beds. Caninia scarce. Broken brachiopods and crinoids . .	71	1083
7	Limestone as in unit 3, forms highest nob on ridge at south end	64	1019

Unit No.	Description	Thickness in feet	Feet above base
6	Limestone: fine to medium grained, very dark maroon-gray, medium bedding forms cliff. Hashy in part (crinoidal). Some poorly preserved brachiopods	24	995
5	Talus and rubble slopes	57	938
4	Limestone: tuffaceous and siliceous in lowermost part, color is dark maroon which grades into a calcarenite. Upper part is alternate gray-brown maroon and light gray-green. Bryozoan abundant; fusulinids, crinoids. At the top of this unit where the rock is exposed above the talus, there is prominent folding	156	782
3	Talus covered slopes	97	685
2	Limestone: medium grained fossil hash, weathers medium gray-blue in lower part. Upper part weathers brown. Steep slope forms. Fusulinids, <u>Caninia</u>, and <u>Syringopora</u>. Also brachiopods	149	536
1	Limestone: fine to medium crystalline, very light gray, weathers the same color. Limestone is a crystallized fossil hash with fossil fragments showing on the weathered surface. Crinoids 2 mm., bryozoans (ramous), small brachiopods, some fusulinids. Limestone massive, fractured, blocky. Bedding very poorly exposed, forms 20° slope. The crystallinity changes from fine to medium, and in places is coarsely crystalline. In the middle they appear to be cemented by a micritic calcite ooze with light crystallinity. There are intermittent beds (scarce) of siliceous bryozoans. Some <u>Fenestrella</u> and others. Base is snow covered	197	336

Scud River Lower Section - Measured from top down.
(Sec. 26)

Unit No.	Description	Thickness in feet	Feet above base
1	Limestone: light brown to very light brown, weathers light gray, massive dense bioclastic in fine grained limestone matrix, looks almost porcelainous to translucent. Weathers pocked surface and breaks into angular blocks. Ledge and cliff former, top faulted and intruded. Crinoids	134	2056
2	Limestone as unit 1, but less ledge-former and less irregular bedding. Bedding still very obscure	119	1937
3	Limestone as unit 1 but with rare 3"-4" dolomite blotches and joint surfaces, massive ledges, becomes very light gray-brown and light yellow. Gray to bottom, lower is semi-ledge zone	128	1809
4	Limestone: light brown to very light yellow-brown, weathers light gray to light brown-gray, thick obscure bedding - massive, dense homogeneous bioclastics in very fine crystalline mud limestone, abundant crinoids, bryozoans. A few blotchy beds very light gray to light gray, fine to medium gray dolomite with calcareous matrix between rhombs. Semislope	72	1737
5	Same as unit 4 but unbedded massive ledges .	105	1632
6	Limestone as unit 4, base dense massive limestone	51	1581
7	Limestone and dolomite interbedded in 4'-8' units; dolomite 2 times as common, limestone as in unit 4 but same light to medium light beds; dolomite light to very		

Unit No.	Description	Thickness in feet	Feet above base
(7)	light yellow-gray. Calcite very finely crystalline, medium bedded, dense homogeneous forms semislope gray-yellow zone.	55	1526
8	Limestone: light-medium to light gray, dense, very finely crystalline with fine grained bioclastic in mud matrix with 1/3 dolomite in blotches - very finely crystalline, very light gray. All ledge former, bryozoans common. Irregular dark gray and medium gray chert lenses . .	69	1457
9	Dolomite: light to light gray and gray-brown, irregular and obscurely bedded, chert rare. Dolomite, calcite, very finely crystalline with abundant fossil "ghosts", fusulines, bryozoans, crinoids	75	1382
10	Dolomite as unit 9 but with approximately 1/4 light to medium gray and yellow-gray chert in 6"-1' beds, weathers medium yellow-gray and brown-yellow gray, forms prominent yellow-gray ledge zone.	116	1266
11	Limestone: medium to light gray, fine grained bioclastic, medium bedding, chert beds medium gray	14	1252
12	Limestone: medium to dark gray, dark gray-brown, medium thick bedding. Limestone dense, fine grained, has some organic-rich, fetid. Slope zone	67	1185
13	Limestone: dark gray-black, finely to very finely crystalline dolo-clastic. Weathers light medium gray, semi-slope to semi-ledge, abundant black chert nodules, abundant siliceous fossil hash at base.	106	1079

Unit No.	Description	Thickness in feet	Feet above base
14	Limestone: black, weathers light medium gray with abundant black nodular chert which weathers black to yellow-brown. Cliff zone, limestone finely crystalline bioclastic	110	969
15	Limestone: black to very dark gray, thin to thick bedding, very cherty in part, abundant crinoids. Cliff zone, chert appears cyclic in 10'-30' with 2'-3' black chert at base, then nodular chert for few feet, then isolated 3"-8" nodule, then reverse. Neospirifer, productids, crinoids, bryozoans, most hashy	131	838
16	Limestone: light medium to medium gray, very fine grained bioclastic. Abundant chert	7	831
17	Dolomite: light gray, finely crystalline, dense, thick bedding, cherty	8	823
18	Limestone: dark gray-black with abundant black nodular chert beds and abundant siliceous fossils. Brachiopods, fusulines, corals, crinoids. Thin to medium bedded ledge zone.	77	746
19	Limestone as unit 18 but chert 1/4 rock, forms prominent ledge above yellow-brown slope zone.	57	689
20	Limestone: black to dark gray-brown, weathers medium orange-gray and medium gray with medium orange, weathers black. Chert. Abundant fossils, cliff former, moderately thick bedding, large fusulines . .	44	645
21	Limestone as in unit 20 but orange stained. Some thin dolomite which is finely crystalline, light medium gray, dense, slightly calcareous. All in cliff zone; many		

Unit No.	Description	Thickness in feet	Feet above base
(21)	beds coarse bioclastic and coquinoid fusulines, bryozoans in lower part. Lower 1/3 poorly exposed, may be faulted in lower poorly exposed zone	154	491
22	Limestone: black to very dark gray, weathers medium gray with orange surface, thick to medium bedding, abundant fossils as above. Chert less common, upper 20' nearly chert free. Some beds dolomitized and with chert mosaic near cherty beds; all coarse. Medium bioclastic in fine limestone mud matrix.	82	409
23	Limestone as in unit 22 but very little chert. Cliff zone in upper part, very tuffaceous in lower few feet	87	322
24	Limestone: black to dark gray, weathers light gray, light medium gray, thick bedding, chert very rare. Finely crystalline to fine grained bioclastics cliff zone. Bedding wavy, fossils abundant and in situ in some beds	44	278
25	Limestone: dark gray to black, others medium gray; some sandy beds, thin bedding. Siliceous streaks on bioclastic fetid coquina	19	259
26	Limestone as in above section but with 1/5 interbedded black chert. Small fusulines coquina, abundant	87	172
27	Limestone: black fusuline coquina, thin bedding weathers orange-gray from black to dark gray. Dense, fetid. Basal beds pebble conglomerate, limestone pebbles in limestone matrix; small fusulines in both matrix and blocks. Little chert	95	77
28	Cover - major fault, ice	28	49
29	Limestone as in units 1 to 6. Fault repeated .	29	20
30	Covered by glacial till	20	0